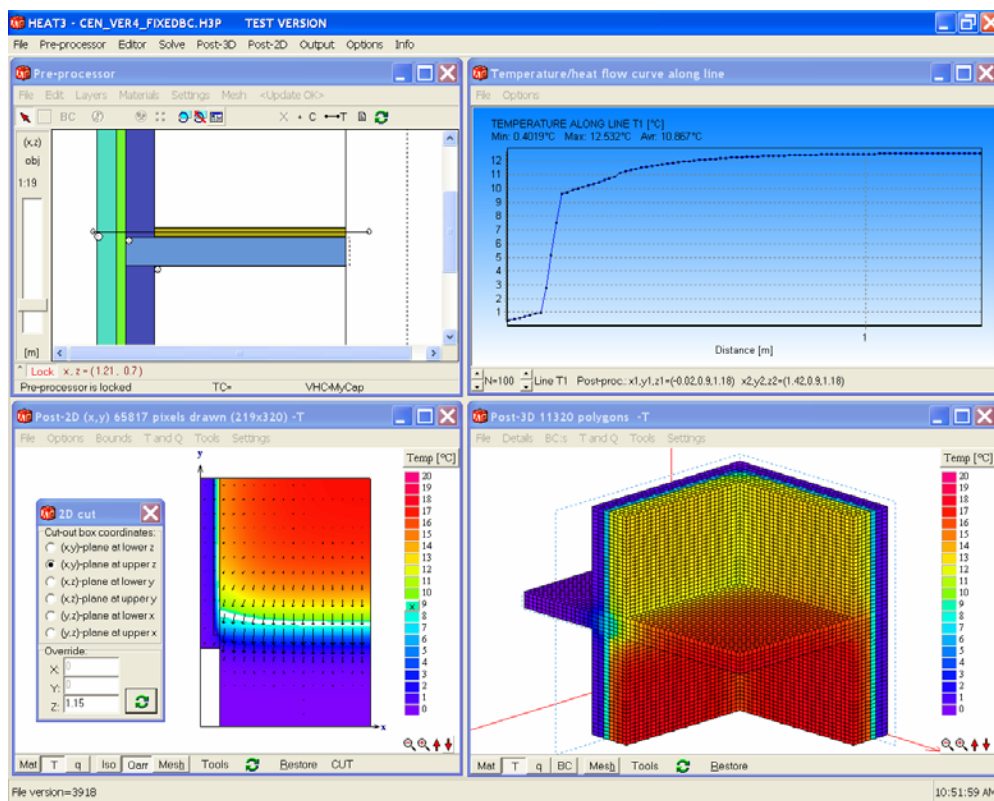


HEAT3 5.0

A PC-program for heat transfer in three dimensions

Update manual



October 10, 2005

BLOCON

www.buildingphysics.com

Contents

1.	WHAT'S NEW IN HEAT3 VERSION 5	4
1.1	AUTOMATIC MESH GENERATION	4
1.2	THERMAL COUPLING COEFFICIENT ANALYSES	4
1.3	POST-PROCESSING IN 2D AND 3D	4
1.4	FASTER CALCULATIONS.....	4
1.5	MOVIE MAKER	4
1.6	TEMPERATURES AND HEAT FLOWS ALONG LINES	4
1.7	REPORT GENERATOR.....	4
1.8	ENHANCEMENTS IN THE MATERIAL LIST	5
1.9	BATCH JOBS	5
1.10	INCREASED SIZES FOR DATA FIELDS	5
1.11	OTHER CHANGES.....	5
2.	AUTOMATIC MESH GENERATION.....	6
2.1	INTRODUCTION	6
2.2	MESH FACTOR FOR FINER GRIDS.....	6
3.	ESTIMATION OF MORE ACCURATE HEAT FLOWS.....	8
4.	THERMAL COUPLING COEFFICIENTS (L^{3D})	9
4.1	INTRODUCTION	9
4.2	EXAMPLE	9
4.3	CALCULATION OF HEAT FLOWS USING THE L^{3D} MATRIX	12
4.4	CALCULATION THE L^{3D} MATRIX WITH HIGH PRECISION	13
4.5	COUPLING BETWEEN GROUPS	13
4.6	TIPS	14
5.	POST-PROCESSING IN 2D.....	15
5.1	INTRODUCTION	15
6.	REPORT GENERATOR	17
7.	MOVIE MAKER	18
7.1	HOW TO MAKE A MOVIE	18
7.2	HOW TO MAKE AN AVI-FILE	19
8.	TEMPERATURES/HEAT FLOW ALONG LINES	20
8.1	DRAWING OPTIONS	20
8.2	DRAWING A TEMPERATURE LINE IN THE PRE-PROCESSOR	20
8.3	DRAWING A TEMPERATURE LINE USING MANUAL COORDINATES	21
9.	ENHANCEMENTS IN MATERIAL LIST	22
9.1	HIERARCHICAL STRUCTURE	22
9.2	DEFAULT MATERIAL FILE	23
10.	BATCH JOBS	24
10.1	BATCH JOB OPTIONS.....	24
10.2	RUNNING MULTIPLE BATCH JOBS.....	25
11.	MISCELLANEOUS NEW FEATURES AND CHANGES.....	26
11.1	RECORDER	26

11.2	OPTIMIZATION OF RELAXATION COEFFICIENT	27
11.3	DEFAULT STOP CRITERION FOR STEADY-STATE.....	27
11.4	ENHANCEMENTS IN PRE-PROCESSOR	28
11.5	SAVING DESKTOP STATE	28

1. What's new in HEAT3 version 5

Blocon is proud to present a new version of HEAT3. It has been four years since version 4 was released and many new important features have been added. Up-to-date information is given on www.buildingphysics.com and www.buildingphysics.de (in German).

This update manual covers new features (see list below) that have been added since version 4. New users should also read the full manual for version 4 at

http://www.buildingphysics.com/manuals/HEAT3_4.pdf

1.1 Automatic mesh generation

HEAT3 can automatically perform steady-state calculations with gradually refined meshes. The user does not have to think about how to give a proper mesh - HEAT3 does this. The mesh criterion from EN ISO 10211 can be applied.

1.2 Thermal coupling coefficient analyses

HEAT3 automatically calculates the thermal coupling coefficients (L^{3D}) according to EN ISO 10211 for a wide variety of problems involving thermal bridges.

1.3 Post-processing in 2D and 3D

The post-processing features have been extended. Charts for temperatures, isotherms, extended heat flow plots, and heat flow arrays are available. A new 2D post-processor (similar to the one in HEAT2 6.0) has been developed.

1.4 Faster calculations

The relaxation coefficient is now optimized during the calculation. As an extreme example, a slab on the ground problem with 570 000 nodes took 100 seconds to solve with optimization. Without optimization this calculation needed 640 seconds when the default value for the relaxation coefficient of 1.95 was used.

The time for steady-state calculations is lowered by 20-50% for most cases. This optimization is made by default but can be turned off (menu item *Solve/Options for steady-state*).

1.5 Movie Maker

The Movie Maker captures graphical output data (2D and 3D), such as temperatures, isotherms, and heat flows and makes a standard AVI-file.

1.6 Temperatures and heat flows along lines

It is now possible to draw lines in the pre-processor and chart the temperatures (or heat flow intensities) along the lines.

1.7 Report Generator

The Report Generator produces on-the-fly a printable document with optional text and figures with project info, and input/output data.

1.8 Enhancements in the material list

The material list is now searchable. Thermal properties may be shown in the material pick list after the material name. It is possible to have a hierarchical structure with two levels for the material list. Material files (*.mtl) are compatible and sharable with HEAT2 version 6.

1.9 Batch jobs

Multiple consecutive simulations may be started externally via batch files.

1.10 Increased sizes for data fields

Many data fields have been increased in sizes. The maximum number of numerical nodes has been doubled from 1000000 (100·100·100) to 2197000 (130·130·130) in the standard version.

HEAT3 5.0 with 2.2 million nodes requires only about 80 MB RAM (a pc with 256 MB is recommended), and less than 5 MB hard disk space. The input data file sizes (*.H3P) are as usual only a few kB large.

The maximum number of polygons (each cell that is adjacent to a boundary) that can be showed in the post-processor is extended from 50000 to 80000.

Special versions of HEAT3 with huge array sizes (e.g. 50 million nodes which needs 1.6 GB ram) are available, see homepage.

1.11 Other changes

Hundreds of minor improvements are made. The most important are shown below:

- Enhancements in pre-processor
- Desktop (placement and sizes of windows) may be saved/read (menu item *Options*)
- Estimation of better heat flows based on calculations with different meshes
- New routines for interpolation of temperatures with higher accuracy
- Export data for graphs in different formats (text, Excel, HTML, XML, Metafile, bitmap)
- Toggling from HEAT3 4.0 to another program and back again would sometimes close down several windows in HEAT3. This is now fixed.
- The chart window for the recorder can now show multiple graph lines in the same chart.
- Improved generation of expansive meshes: the expansion in each direction is made so that the smallest cell has the same size in all three dimensions (the smallest cell will have the shaped of a cube).

Enhancements in post-processing:

- Window content may be zoomed to a much higher limit than before
- Faster drawing/updating
- Color plots (in 2D and 3D) of heat flow can be viewed for different direction components (perpendicular to surface (q_z), along surface (q_x, q_y), or for all directions (q_x, q_y, q_z))

2. Automatic mesh generation

2.1 Introduction

There is a numerical error due to the mesh. A finer mesh grid with small cells gives more accurate results compared to a coarse grid with large cells. HEAT3 can automatically perform steady-state calculations with gradually refined meshes. The following mesh criterion from EN ISO 10211 can be applied. The sum of the absolute values of all heat flows entering the object is calculated twice, for n cells and for $2n$ cells. The relative difference between the flows must be smaller than 2%, otherwise a new mesh division is required.

2.2 Mesh factor for finer grids

Menu item *Solve/Automatic mesh and L3D* brings up the **Automatic mesh window**, see Figure 2.1. The mesh factor describes how much the number of cells should increase in each direction for the new finer grid. The default value for this factor is 1.5 in HEAT3. Figure 2.1 shows the CEN case 1 (see EN ISO 10211 or the manual for HEAT3 4.0) with calculations for five levels of refined meshes.

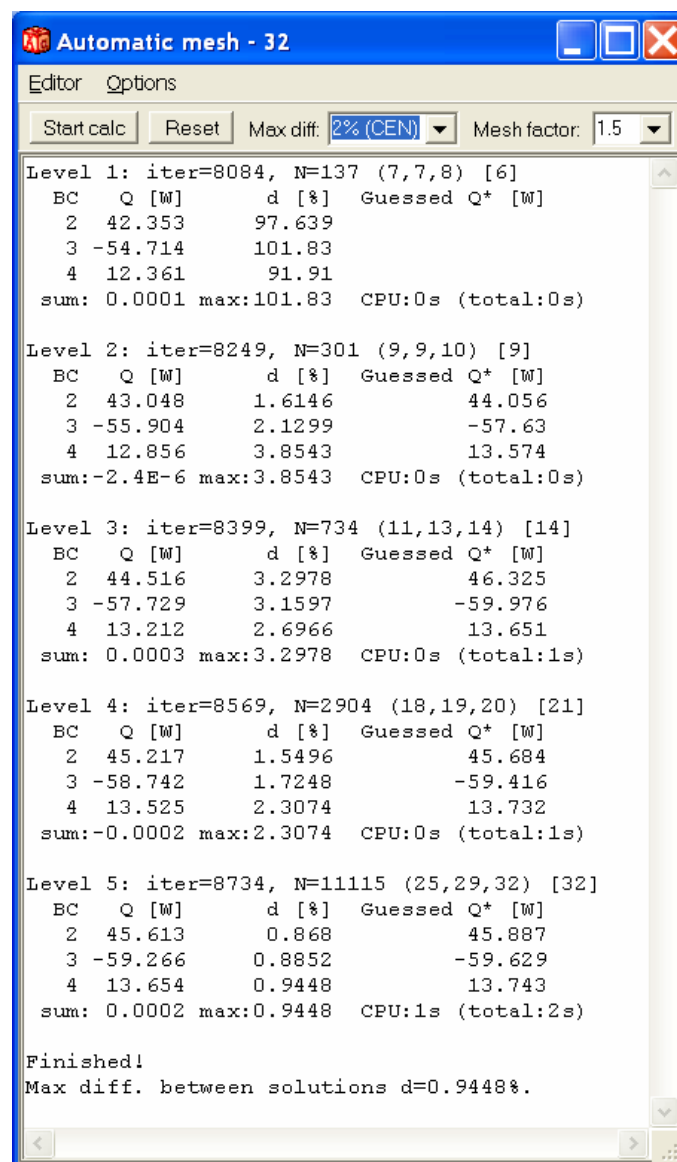


Figure 2.1: The automatic mesh window with calculated results.

Press button *Start calc* to begin the analyses. Consider e.g. level 3 that has [14] cells in the widest direction. This will generate a mesh with $11 \cdot 13 \cdot 14$ cells (the total number of cells is here $N=734$). The next level has $1.5 \cdot 14 = [21]$ cells in the widest direction ($18 \cdot 19 \cdot 20$ cells). Due to irregular geometry the resulting mesh increase value is not exact.

The division into finer grids will continue until the maximum difference of the heat flow through the boundaries between consecutive solutions becomes smaller than a specified value d (*Max diff*). This value is by default 1% (the EN ISO 10211 criterion is 2% but this value may not be sufficient).

Consider once again level 3 and 4. The heat flow through all surfaces with boundary condition number 4 is 13.212 W for level 3 and 13.525 W for level 4. The difference is $1 - 13.212 / 13.525 = 2.31\%$. The guessed heat flow Q^* is explained in chapter 3.

The last level fulfills the 1% difference criterion. The total simulation time on a Pentium 4 (2.7 MHz) was for all levels about two seconds.

Note that the calculation for each level is finished when the steady-state stop criterion for boundary flows is fulfilled, see Figure 11.2. The sum of all heat flows (positive and negative) entering the boundary surfaces Q_b , divided by the sum of the absolute values of all these heat flows, must be less than a given value F (by default 0.01% in HEAT3).

3. Estimation of more accurate heat flows

More accurate heat flows can be obtained by combining results from two or three solutions with different meshes. For more information about this topic, please see chapter 4.2 in the thesis by Blomberg “Heat conduction in two and three dimensions” at

http://www.buildingphysics.com/manuals/avh_TB.pdf

Figure 2.1 in Chapter 2 shows the guessed heat flow Q^* that is calculated by combining results from the two last simulations.

Consider e.g. the heat flow for boundary condition BC=2 for level 5. The calculated value is 45.613 W and the estimated better value is 45.886. The calculated “true” heat flow with an infinite number of cells is actually 46.1 W for BC=2 (60.0 W for BC=3 and 13.9 W for BC=4). This gives a numerical error for the calculated value 45.613 of 1.1%, and 0.5% for the guessed value 45.886.

At least two numerical calculations are needed to check the 2% criterion in the EN ISO 10211 standard mentioned in Chapter 2. It is therefore a good idea to use results from two or three simulations to obtain more accurate heat flows.

There is also an option to make such an estimation by hand in HEAT3. Figure 3.1 shows a dialogue for guessing better heat flows by combining different meshes, see menu item *Output/Guess heat flow/temperature*. Here data is entered for levels 3, 4 and 5, see Figure 2.1. Using the two last results [2+3] gives a guessed heat flow of 45.887, using all three results [1+2+3] gives a heat flow of 46.167 (a 0.1% error compared to the true result 46.1).

	1	2	3
N:	734	2904	11115
V:	44.5160	45.2170	45.6130

Results:

1+2: 45.684
2+3: 45.887
1+2+3: 46.167

Guess Close

Figure 3.1: Dialog for guessing better heat flows/temperatures by combining results from different meshes.

Note that for some cases, a solution for three levels may not be found.

Estimations of more accurate temperatures can be done in the same way as with heat flows by substituting the heat flows ($V1$, $V2$, $V3$) with temperatures.

4. Thermal coupling coefficients (L^{3D})

4.1 Introduction

HEAT3 automatically calculates the thermal coupling coefficients (L^{3D}) according to EN ISO 10211 for a wide variety of problems involving thermal bridges. To calculate the L^{3D} matrix, check the menu item *Options/Calculate L3D* in the automatic mesh window, see Figure 2.1 in Chapter 2.

The thermal coupling coefficient matrix will have $n \cdot n$ number of columns and rows where n is the number of different boundary conditions with a specified temperature. HEAT3 will automatically make n calculations. There may be up to 9 different boundary temperature conditions (giving a 9-9 L^{3D} matrix).

The 3D point thermal transmittance (χ) can be calculated by hand according to EN ISO 10211.

4.2 Example

Consider case 1 in EN ISO 10211 that has three different boundary temperatures, see Figure 4.1.

The screenshot shows the 'Boundary conditions (F6)' dialog box. It has a title bar with a red icon and standard window controls. Below the title bar, there is a 'Number of types:' field set to 4 and a 'Get L3D flows' button. A table with 5 columns is displayed: '<n>', 'type', 'q [W/m²]', 'T [°C]', and 'R [m²·K/W]'. The table contains 4 rows. Row 1 is '1', 'Q=const', '0.00000', empty, empty. Row 2 is '2', 'T=const', empty, '20.00000', '0.200000'. Row 3 is '3', 'T=const', empty, '0.00000', '0.050000'. Row 4 is '4', 'T=const', empty, '15.00000', '0.200000'. At the bottom, there are 'Close' and 'Update' buttons.

<n>	type	q [W/m²]	T [°C]	R [m²·K/W]
1	Q=const	0.00000		
2	T=const		20.00000	0.200000
3	T=const		0.00000	0.050000
4	T=const		15.00000	0.200000

Figure 4.1: Original boundary temperatures for the EN ISO 10211 case.

Press button *Start calc* (see Figure 2.1) to begin the analyses. The first calculation will give the first row (which is the same as the first column by symmetry) of the L^{3D} matrix. Here the boundary temperatures of type 2 will be substituted automatically with $T=1$. All other boundary conditions temperature types will have $T=0$, see Figure 4.2.

The screenshot shows the 'Boundary conditions (F6)' dialog box after the first calculation. The table is identical to Figure 4.1, but the temperature values have been updated. Row 2 now has '1.00000' in the 'T [°C]' column. Rows 3 and 4 now have '0.00000' in the 'T [°C]' column. The 'q [W/m²]' column remains empty for all rows. The 'Close' and 'Update' buttons are still at the bottom.

<n>	type	q [W/m²]	T [°C]	R [m²·K/W]
1	Q=const	0.00000		
2	T=const		1.00000	0.200000
3	T=const		0.00000	0.050000
4	T=const		0.00000	0.200000

Figure 4.2: The first calculation gives the first row of the L^{3D} matrix.

The last two calculations give the second and third row of the L^{3D} matrix, see Figure 4.3.

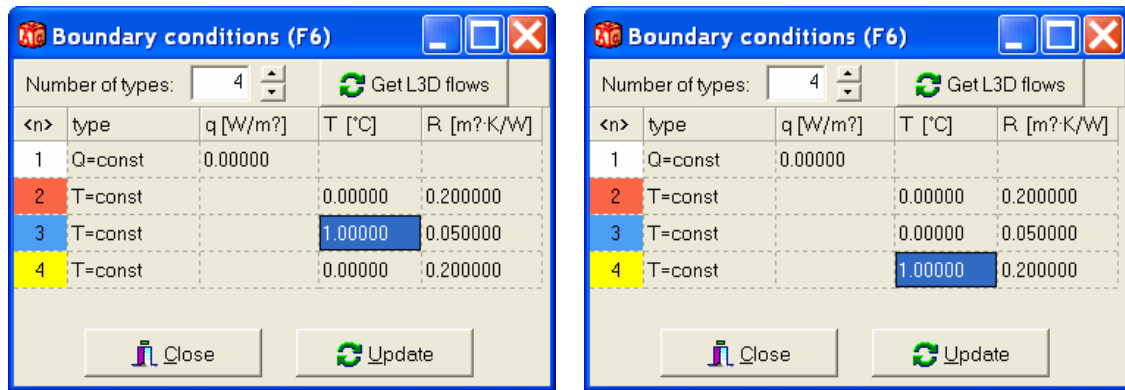


Figure 4.3: The last two calculations give the second and third row of the L^{3D} matrix.

The following output results will be presented in the automatic mesh window. Each case will be simulated with different meshes according to Chapter 2 to obtain a satisfactory numerical accuracy. Comments are shown in bold-face.

CALCULATION OF L3D FOR BC 2

(levels 1-4 not shown here)

```
.
Level 5: iter=9174, N=11115 (25,29,32) [32]
  BC   Q [W]      d [%]  Guessed Q* [W]
    2   3.8504     0.6255      3.867
    3  -1.7574     1.0473     -1.7702
    4   -2.093     0.2728     -2.0969
sum:-2.2E-5 max:1.0473 CPU:1s (total:2s)
```

Finished!
Max diff. between solutions d=1.0473%.

Thermal coupling coefficients
for BC number 2:
2:2 3.8504 3.867(*)
2:3 -1.7574 -1.7702(*)
2:4 -2.093 -2.0969(*)
(*) estimated better values

CALCULATION OF L3D FOR BC 3
Start number for max cells: [6]

(levels 1-4 not shown here)

```
Level 5: iter=9969, N=11115 (25,29,32) [32]
  BC   Q [W]      d [%]  Guessed Q* [W]
    2  -1.7574     1.0454     -1.7701
    3   3.3653     0.8574      3.3852
    4  -1.6079     0.6533     -1.6152
sum: -1E-5 max:1.0454 CPU:1s (total:2s)
```

Finished!
Max diff. between solutions d=1.0454%.

Thermal coupling coefficients
for BC number 3:
3:2 -1.7574 -1.7701(*)
3:3 3.3653 3.3852(*)
3:4 -1.6079 -1.6152(*)
(*) estimated better values

CALCULATION OF L3D FOR BC 4

Start number for max cells: [6]

(levels 1-4 not shown here)

```
.
Level 5: iter=10759, N=11115 (25,29,32) [32]
BC   Q [W]      d [%]   Guessed Q* [W]
 2   -2.093     0.2729   -2.0969
 3  -1.6079     0.6524   -1.6151
 4   3.7009     0.438    3.7121
sum: 6.9E-6 max:0.6524 CPU:1s (total:2s)
```

Finished!

Max diff. between solutions d=0.6524%.

Thermal coupling coefficients

for BC number 4:

```
4:2  -2.093  -2.0969(*)
4:3  -1.6079 -1.6151(*)
4:4   3.7009  3.7121(*)
```

(*) estimated better values

Thermal coupling matrix L3D [W/K]:

BC	2	3	4
2:	3.8504	-1.7574	-2.093
3:	-1.7574	3.3653	-1.6079
4:	-2.093	-1.6079	3.7009

The final thermal coupling coefficient (L^{3D}) is shown above (W/K). Note the symmetry.

A matrix (L^{3D*}) with estimated more accurate heat flows (see chapter 3) is also presented:

L3D* [W/K] (estimated better values):

BC	2	3	4
2:	3.867	-1.7702	-2.0969
3:	-1.7701	3.3852	-1.6152
4:	-2.0969	-1.6151	3.7121

Boundary heat flows can now be calculated for any arbitrary temperatures. An example with the original boundary conditions (see Figure 4.1) is shown in the output result:

```
Heat flow Q[n] through boundaries with BC[n]:
Q[2]=T[2]*L3D[2,2]+T[2]*L3D[2,3]+T[2]*L3D[2,4]
Q[3]=T[3]*L3D[3,2]+T[3]*L3D[3,3]+T[3]*L3D[3,4]
Q[4]=T[4]*L3D[4,2]+T[4]*L3D[4,3]+T[4]*L3D[4,4]
```

Example. Assume the following temperatures:

BC	T
2:	20 °C
3:	0 °C
4:	15 °C

The heat flows becomes using L3D(*):

```
Q[2]=20*3.867+0*-1.7702+15*-2.0969=45.887 W
Q[3]=20*-1.7701+0*3.3852+15*-1.6152=-59.629 W
Q[4]=20*-2.0969+0*-1.6151+15*3.7121=13.743 W
```

Heat flows using:	L3D	L3D(*)
Q[2]=	45.613	45.887
Q[3]=	-59.267	-59.629
Q[4]=	13.654	13.743

These values are about the same as the results in Figure 2.1.

4.3 Calculation of heat flows using the L^{3D} matrix

When the L^{3D} matrix has been calculated it is possible to get the heat flows for arbitrary temperatures in the boundary conditions input window (short-cut **F6**). Press the menu item *Options/Get current BC temperatures and calculate flows* in the automatic mesh window or press (F6), see Figure 4.4.

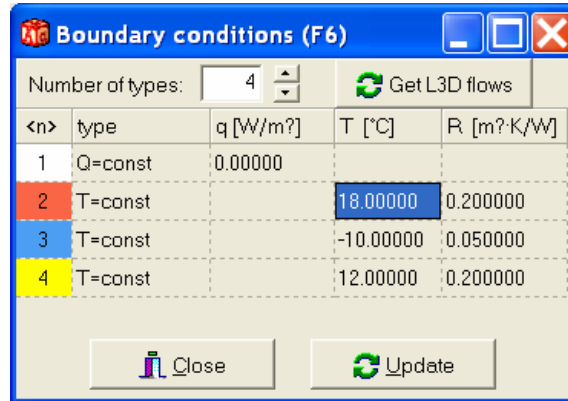


Figure 4.4: Press *Get L3D flows* to obtain the flows directly using the L^{3D} matrix .

Assume new boundary temperatures according to Figure 4.4. Press the button *Get L3D flows* to obtain the boundary flows directly using the L^{3D} matrix. The following will be written to the automatic mesh editor:

Thermal coupling matrix L3D [W/K]:

```
BC      2      3      4
2:    3.8504  -1.7574  -2.093
3:    -1.7574  3.3653  -1.6079
4:    -2.093  -1.6079  3.7009
```

L3D* [W/K] (estimated better values):

```
BC      2      3      4
2:    3.867  -1.7702  -2.0969
3:    -1.7701  3.3852  -1.6152
4:    -2.0969  -1.6151  3.7121
```

Heat flow Q[n] through boundaries with BC[n]:

```
Q[2]=T[2]*L3D[2,2]+T[2]*L3D[2,3]+T[2]*L3D[2,4]
Q[3]=T[3]*L3D[3,2]+T[3]*L3D[3,3]+T[3]*L3D[3,4]
Q[4]=T[4]*L3D[4,2]+T[4]*L3D[4,3]+T[4]*L3D[4,4]
```

Example. Assume the following temperatures:

```
BC      T
2:    18 °C
3:    -10 °C
4:    12 °C
```

The heat flows becomes using L3D(*):

```
Q[2]=18*3.867+-10*-1.7702+12*-2.0969=62.145 W
Q[3]=18*-1.7701+-10*3.3852+12*-1.6152=-85.096 W
Q[4]=18*-2.0969+-10*-1.6151+12*3.7121=22.952 W
```

Heat flows using:

	L3D	L3D(*)
Q[2]=	61.766	62.145
Q[3]=	-84.581	-85.096
Q[4]=	22.816	22.952

4.4 Calculation of the L^{3D} matrix with high precision

The L^{3D} matrix can be calculated with the highest number of available numerical nodes (see last row **All levels** in the column for “Max diff” d). This will use up to $N=[130]$ in the standard version. The output results become:

Thermal coupling matrix L^{3D} [W/K]:

BC	2	3	4
2:	3.8727	-1.7793	-2.0934
3:	-1.7792	3.4021	-1.6229
4:	-2.0934	-1.6229	3.7163

L^{3D*} [W/K] (estimated better values):

BC	2	3	4
2:	3.8739	-1.7805	-2.0935
3:	-1.7803	3.404	-1.6238
4:	-2.0934	-1.6237	3.7172

Heat flow $Q[n]$ through boundaries with $BC[n]$:

$$Q[2]=T[2]*L^{3D}[2,2]+T[2]*L^{3D}[2,3]+T[2]*L^{3D}[2,4]$$

$$Q[3]=T[3]*L^{3D}[3,2]+T[3]*L^{3D}[3,3]+T[3]*L^{3D}[3,4]$$

$$Q[4]=T[4]*L^{3D}[4,2]+T[4]*L^{3D}[4,3]+T[4]*L^{3D}[4,4]$$

Example. Assume the following temperatures:

BC	T
2:	20 °C
3:	0 °C
4:	15 °C

The heat flows becomes using $L^{3D(*)}$:

$$Q[2]=20*3.8739+0*-1.7805+15*-2.0935=46.076 \text{ W}$$

$$Q[3]=20*-1.7803+0*3.404+15*-1.6238=-59.962 \text{ W}$$

$$Q[4]=20*-2.0934+0*-1.6237+15*3.7172=13.89 \text{ W}$$

Heat flows using:	L^{3D}	$L^{3D(*)}$
$Q[2]=$	46.053	46.076
$Q[3]=$	-59.928	-59.962
$Q[4]=$	13.877	13.89

4.5 Coupling between groups

Note that the coupling is made between groups of different boundary condition **types** that have a prescribed boundary temperature. Figure 4.5 shows e.g. that the three yellow surfaces belong to a group (BC type 4). Each surface can however be linked to one unique BC type if a coupling is of interest to this particular surface.

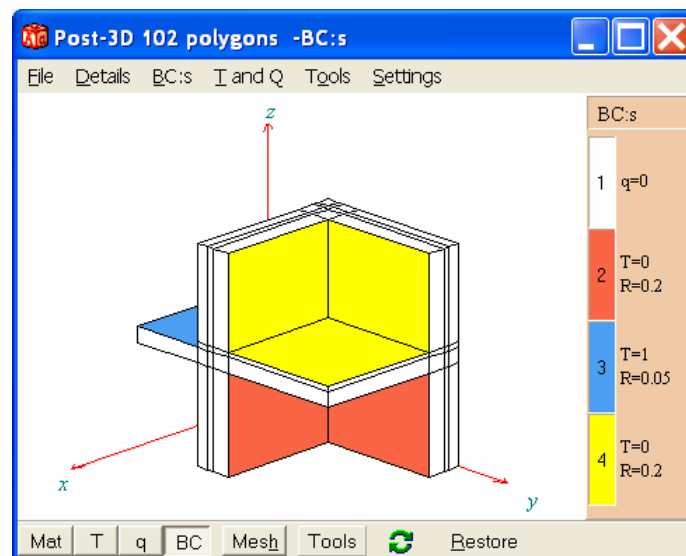


Figure 4.5: Coupling is made between groups of different boundary condition.

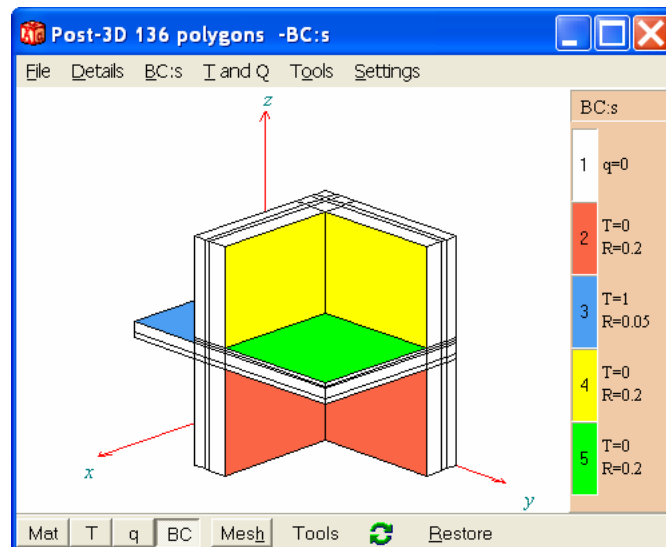


Figure 4.6: Here, the floor surface is linked to a new BC group (green).

In Figure 4.6, the floor surface is linked to a new BC group 5 (green) which will result in a separate coupling for this surface (using **All levels**):

Thermal coupling matrix L3D [W/K]:

BC	2	3	4	5
2:	3.8725	-1.7791	-0.3189	-1.7745
3:	-1.7791	3.4021	-1.2727	-0.3502
4:	-0.3189	-1.2727	1.8156	-0.224
5:	-1.7745	-0.3502	-0.224	2.3487

L3D* [W/K] (estimated better values):

BC	2	3	4	5
2:	3.8737	-1.7802	-0.3193	-1.7742
3:	-1.7802	3.4039	-1.2731	-0.3506
4:	-0.3193	-1.2731	1.8175	-0.2251
5:	-1.7742	-0.3506	-0.2251	2.3499

Using the L^{3D} matrix to obtain the heat flows for e.g the temperatures below gives the following:

Example. Assume the following temperatures:

BC	T
2:	20 °C
3:	0 °C
4:	15 °C
5:	15 °C

Heat flows using:	L3D	L3D(*)
Q[2]=	46.05	46.071
Q[3]=	-59.927	-59.959
Q[4]=	17.496	17.5
Q[5]=	-3.6188	-3.6123

Here, the heat flow up from the floor (green) is 3.61 W (the minus sign denotes a flow from the surface). The heat flow in to the upper walls (yellow) is 17.4 W.

4.6 Tips

The L^{3D} matrix is not saved automatically to the h3p-file or any other output file. It is possible to copy the editor content and save it in another program, such as Word.

Automatic mesh calculation works for both expansive meshes (i.e. expansion point has been drawn in the pre-processor) and for equidistant ones.

Note that the sum of each row (and column) for the L^{3D} matrix should be zero (and that the matrix is symmetric) for the same numerical mesh. This is a good test of that a sufficiently low value for the steady-state stop criterion for boundary flows has been used, see Figure 11.2.

5. Post-processing in 2D

5.1 Introduction

A new 2D post-processor has been developed, see Figure 5.1. Most features are the same as for the post-processor in HEAT2. Please see chapter 5.18 in the HEAT2 manual for basic features at http://www.buildingphysics.com/manuals/HEAT2_5.pdf

The 2D plane cut is chosen by the user. Consider Figure 5.1. The button “CUT” in bottom menu bar (lower right) brings up the “2D cut” menu. The slice cut can be made for one of the six sides for a bounding box for the whole geometry (i.e. “(x,y)-plane at lower z” means the plane cut at the reference level $z=0$).

If a cut-out box has been drawn in the pre-processor, the reference level of the cut-out box coordinates will be used (“(x,y)-plane at lower z” means the plane cut at the minimum z-value for the cut-out box). It is also possible to override the values with post-processor coordinates. In Figure 5.1, the value $z=1.1$ m has been used which gives the (x,y)-plane at this level.

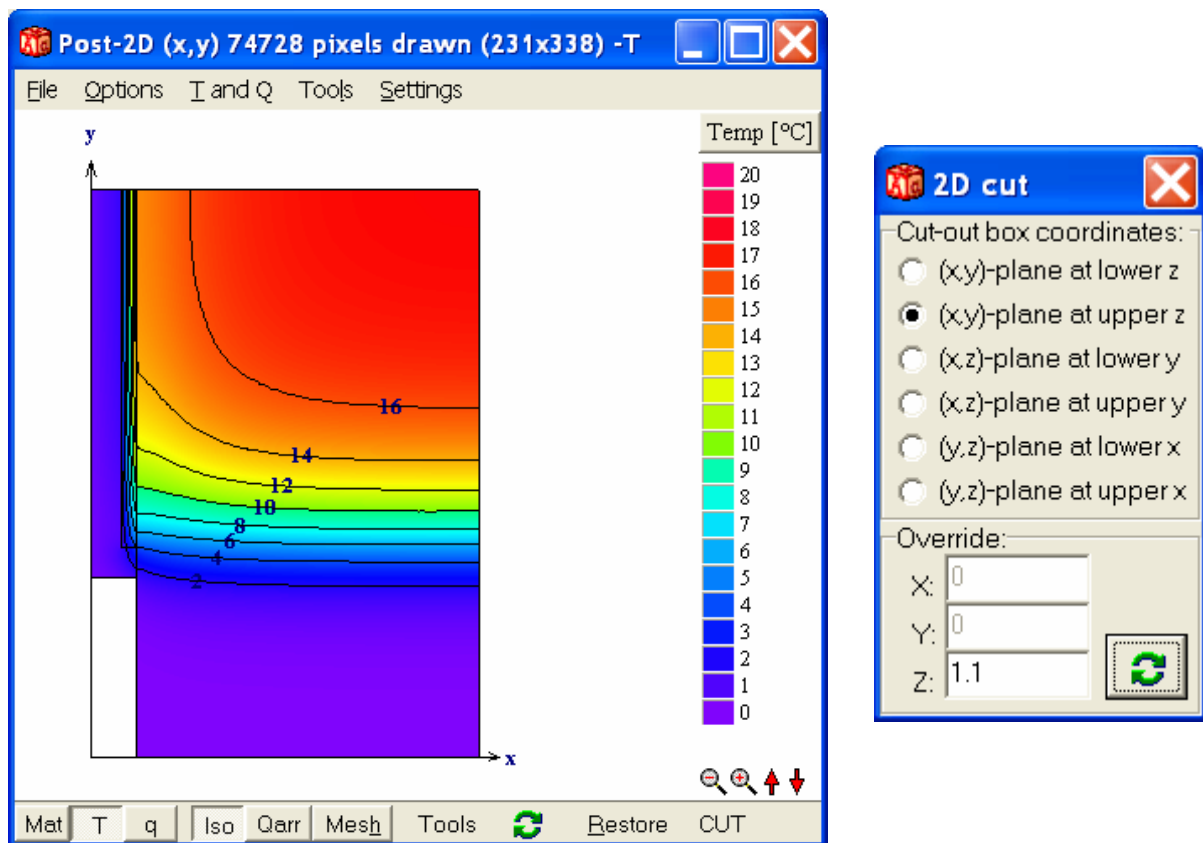


Figure 5.1: The new 2D post-processor.

The following features differ from HEAT2. There are three optional views for the heat flow intensities (button **q** in the lower tool bar), see menu in Figure 5.2. The first option shows the resulting value in the (x,y,z)-direction. The second considers only the plane components (x',y'), the third one shows only the component perpendicular to the plane (z'). These options are the same in the 3D post-processor.

Heat flows array magnitudes always represents plane components only.

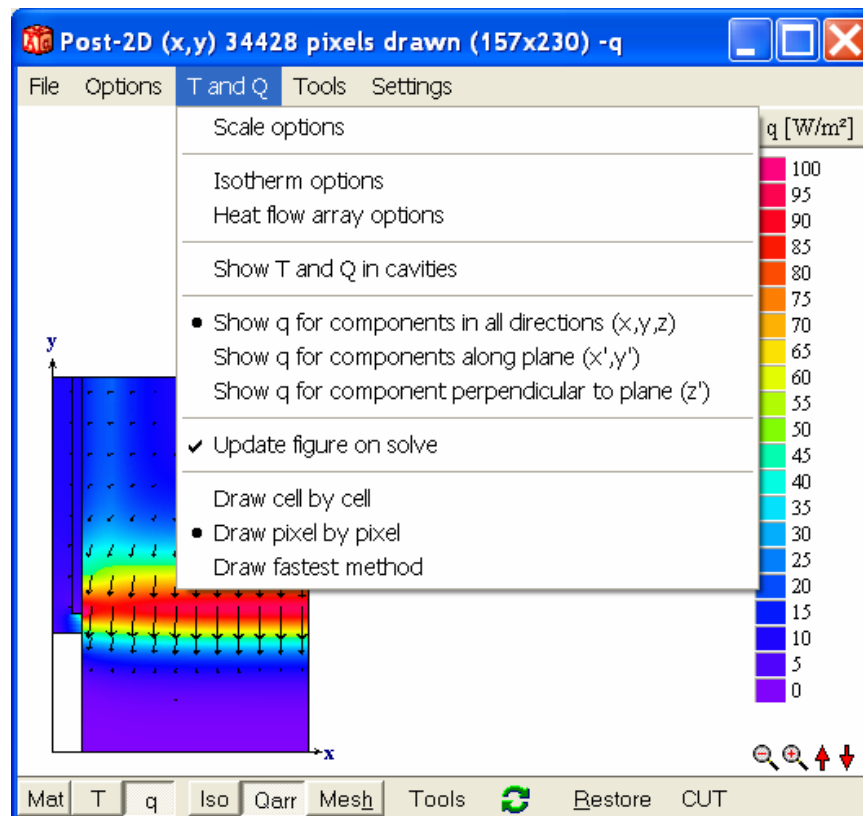


Figure 5.2: Heat flow intensities and arrays drawn.

6. Report Generator

The Report Generator produces on-the-fly a printable document with optional text and figures with project info, and input/output data (see menu item “Output/Report preview F2”). Figure 6.1 shows the options for the report (menu item “Output/Report options”) and an example of a report (first page is shown). The Report Generator is similar to the one used in HEAT2 6.0.

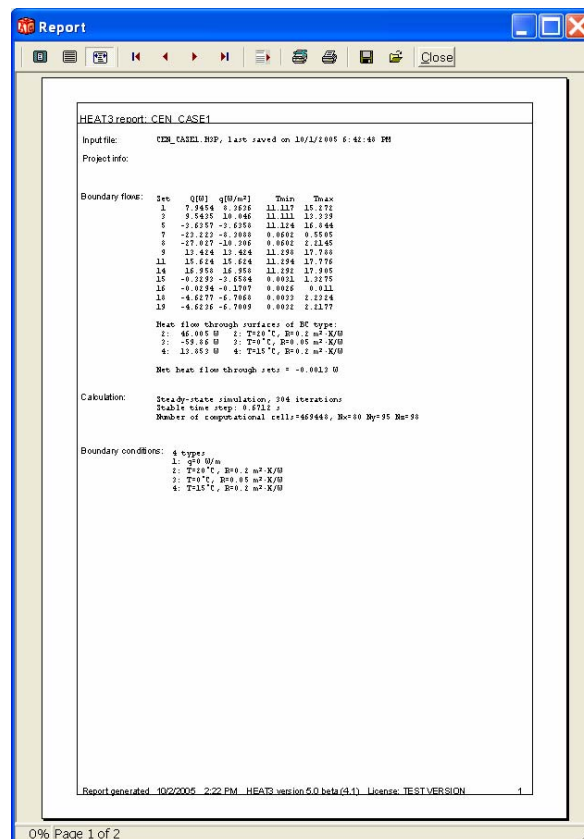
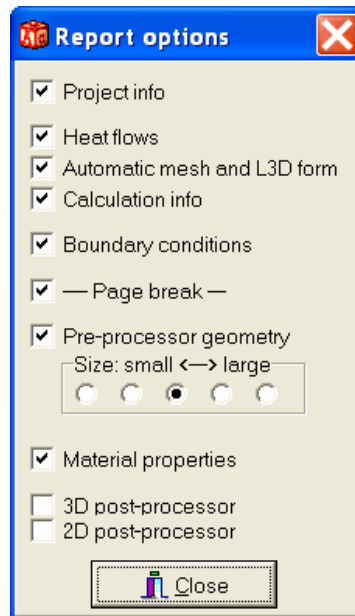


Figure 6.1: Options for report (above) and first page sample (below).

7. Movie Maker

7.1 How to make a movie

The Movie Maker captures graphical output data, such as temperatures, isotherms, and heat flows and makes a standard AVI-file. The AVI-file may optionally be un-compressed (high quality) or compressed (lower quality but smaller size suitable to send by email). Figure 7.1 shows the Movie recorder/player window (under menu item “Output”).

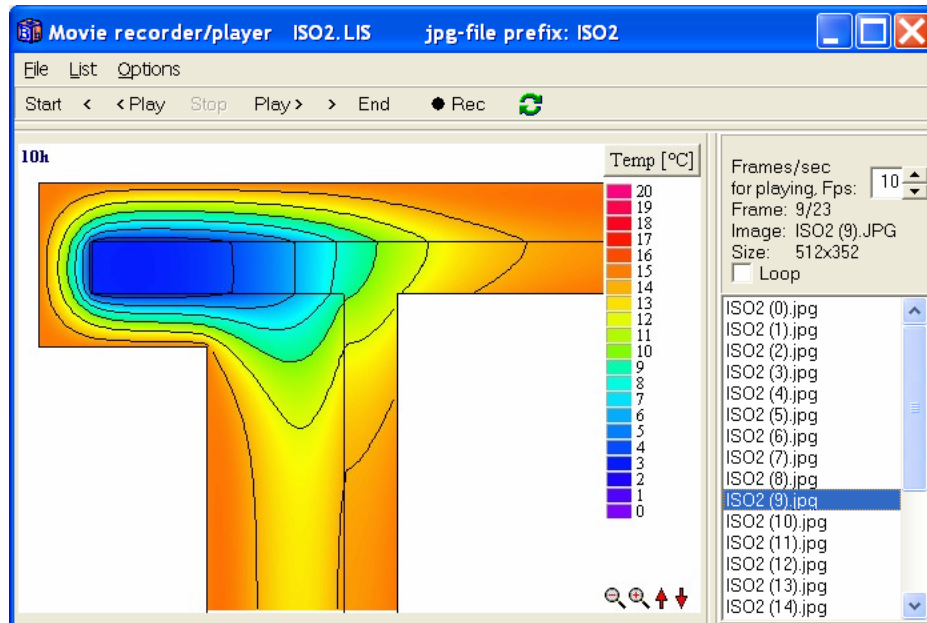


Figure 7.1: The Movie recorder/player window.

A “movie” is defined by a list of JPG-files. First, a list file name is chosen (Figure 7.1 shows a list called “ISO2.LIS”). This file list (*.LIS) may be saved/opened to/from the hard disk.

The Movie recorder captures frames from the post-processor on each screen update (specified in menu item “Solve/Update interval”). The frames are captured and saved to the hard disk as JPG-files beginning with the list file name plus a counter. The list file itself is just a text file with the JPG-files:

```
ISO2 (0) .jpg  
ISO2 (1) .jpg  
ISO2 (2) .jpg  
ISO2 (3) .jpg  
...
```

The JPG-files and the referring LIS-file must be in the same hard-disk folder.

Making a movie involves the following steps:

1. Prepare the desired content of the post-processor (2D or 3D), e.g. temperatures and isotherms/zooming of geometry/scale options/isotherms/heat flow arrays/etc. Be careful when choosing the window size for the post-processor: the larger the size, the larger the captured frames (and resulting AVI file) will be.
2. For transient cases, the simulation time can be displayed in the upper left corner in the 2D post-processor (menu item “Options/Show simulation time”).
3. Give a proper update interval (menu item “Solve/Update interval”) between capturing.
4. Open the Movie recorder (menu item “Output/Movie recorder/player”). Choose menu item File/new and give a name for the LIS-file. Tip: place the lis-file in the “Movie folder”. There

will be many jpg-files created and it might be good to keep them separated from the HEAT3 folder.

5. Select *Capture post-2D window* or *Capture post-3D window* under menu item *Options*.
6. Press the REC-button (this will turn red on record mode). Note that it is now not possible to change the post-processor window size (exporting to AVI-format requires this). Start the simulation. The frames will now be captured. To stop recording, press the REC-button again.
7. Now the movie can be shown using the “Play”-button. Check the “Loop”-box to have a continuous show.
8. Don’t forget to save the list to hard disk (the captured JPG-files are already saved).

The number of frames per second (FPS) for viewing can be adjusted on the right-hand side panel. Note that the performance depends on how fast computer/graphics card is available.

Note: If a captured frame has a name that already exists (already a JPG-file with that name on the hard-disk), a new name will be given to it. E.g. if ISO2 (4).jpg already exists, it will be saved as ISO2 (4_1).jpg instead. Also, this name will be correctly added to the list.

7.2 How to make an AVI-file

A movie can be exported into an AVI-file. In fact, there are 11 different formats that may be used. It may optionally be un-compressed (high quality) or compressed (lower quality but smaller size suitable to send by email), see Figure 7.2. All formats are playable by ordinary AVI-players (such as Microsoft’s Windows Media Player). HEAT3 also have a simple internal AVI-player (menu item Output/AVI-player).

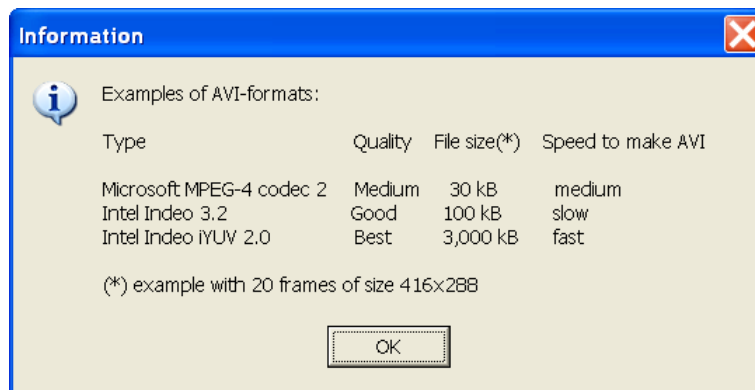


Figure 7.2: Examples of AVI-formats.

To convert a movie to an AVI use menu item “File/Export to AVI”. Note that the given the number of frames per second (FPS) will affect the final AVI-file when it is played.

Note: some AVI-formats may not work due to operating system and size of jpg-files. If a format does not work, please try another one.

8. Temperatures/heat flow along lines

It is now possible to draw lines in the pre-processor and chart the temperatures (or heat flow intensities) along the curves. The charts can be printed and the data for each line can be exported in different formats (text, Excel, HTML, XML, Metafile, bitmap).

8.1 Drawing options

The temperature/heat flow window is reached by menu item “Temperature along line/boundaries”. Figure 8.1 shows the drawing options.

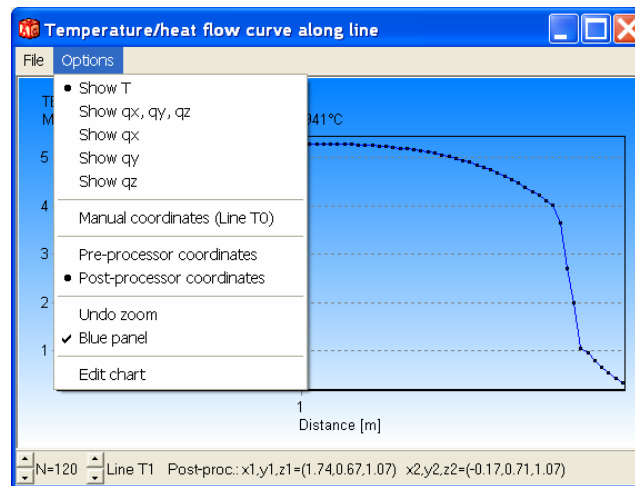


Figure 8.1: Drawing options.

8.2 Drawing a temperature line in the pre-processor

There is a new tool on the upper tool bar in the pre-processor to draw “temperature lines”. Figure 8.2 shows two drawn lines. Figure 8.3 shows the temperatures along line 1. Press the up-down button in the lower left corner to change to line 2. Coordinates can be shown for pre-processor coordinates or post-processor coordinates, see drawing options in Figure 8.1.

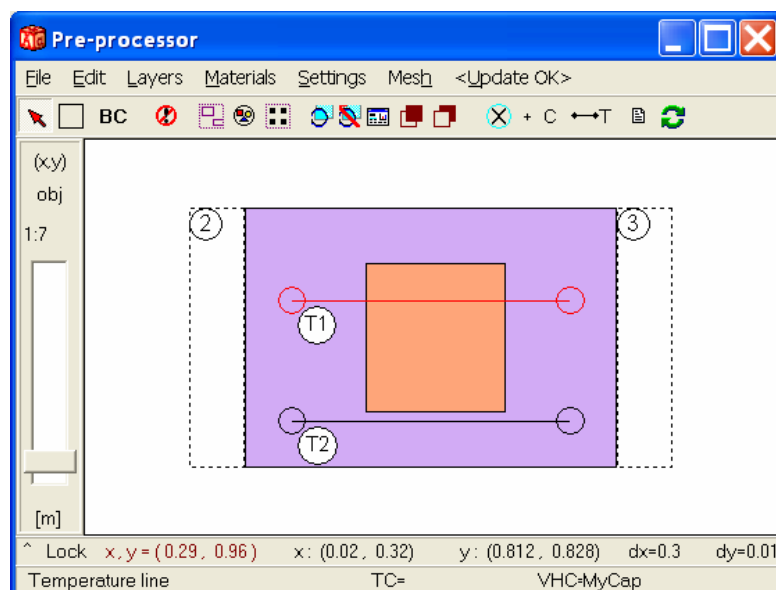


Figure 8.2: Two temperature lines drawn in the pre-processor.

8.3 Drawing a temperature line using manual coordinates

It is also possible to get data for a line using manual coordinates. This is because geometry can be described using only text input (without using the pre-processor). Only post-processor coordinates (zero-based) can be used, see Figure 8.4.

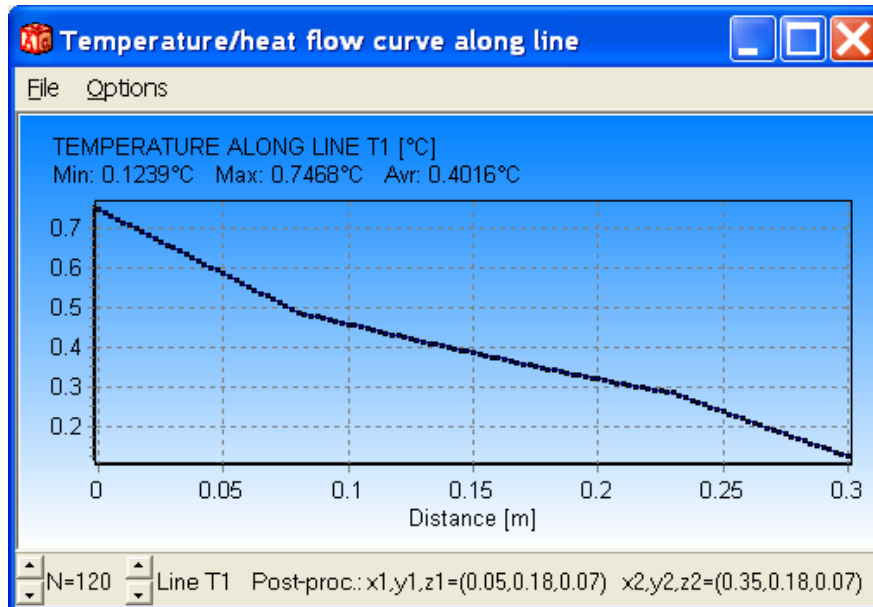


Figure 8.3: Temperatures along line 1.

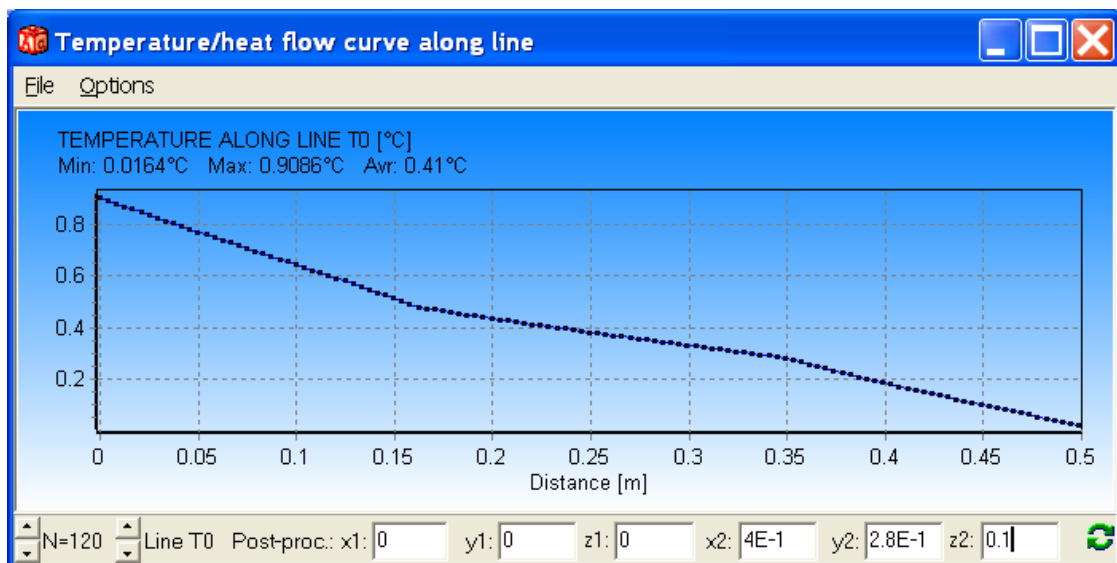


Figure 8.4: Temperatures along manually given line. The line is shown as T0.

9. Enhancements in material list

9.1 Hierarchical structure

The material list is now searchable. Thermal properties may be shown in the material pick list after the material name (see check-box “Show data” in Figure 9.1). It is also possible to have a hierarchical structure with two levels for the material list.

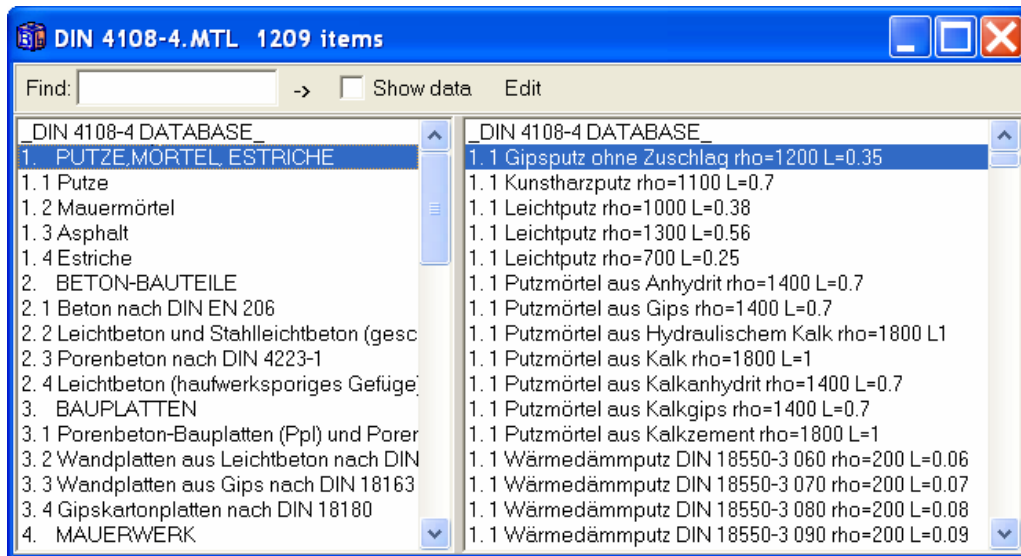


Figure 9.1: Hierarchical structure with two levels for the material list.

A hierarchical structure with a head group (see left pane in Figure 9.1) can be made using the following rules:

1. First item in the ordinary material list is a reference to an index file “_MyIndexFile_” (should begin and end with “_”). The index file is “_DIN 4108-4 DATABASE_” in DIN 4108-4.MTL, see top row in the right pane.
2. The reference file is a text file (“_DIN 4108-4 DATABASE_.txt”), see below.
3. The material names in the ordinary list should have section numbers (e.g.: “1. 1 Leichtputz rho=1000 L=0.38”) in order to be referenced.

```
_DIN 4108-4 DATABASE_.txt:
-----
_DIN 4108-4 DATABASE
1. PUTZE,MÖRTEL, ESTRICHE
1. 1 Putze
1. 2 Mauermörtel
1. 3 Asphalt
1. 4 Estriche
2. BETON-BAUTEILE
2. 1 Beton nach DIN EN 206
2. 2 Leichtbeton und Stahlleichtbeton (geschlossenes Gefüge) nach DIN EN 206 und
DIN 1045-1
2. 3 Porenbeton nach DIN 4223-1
2. 4 Leichtbeton (haufwerksporiges Gefüge) nach DIN 1045-1
3. BAUPLATTEN
3. 1 Porenbeton-Bauplatten (Ppl) und Porenbeton-Planplatten (Pppl) nach DIN 4166
3. 2 Wandplatten aus Leichtbeton nach DIN 18162
3. 3 Wandplatten aus Gips nach DIN 18163
3. 4 Gipskartonplatten nach DIN 18180
4. MAUERWERK
4. 1 Mauerwerk aus Mauerziegeln nach DIN 105-1 bis E DIN 105-6
```

```

4. 2 Mauerwerk aus Kalksandsteinen nach DIN 106
4. 3 Mauerwerk aus Hüttensteinen nach DIN 398
4. 4 Mauerwerk aus Porenbeton-Plansteinen (PP) nach DIN 4165
4. 5 Mauerwerk aus Betonsteinen
5.   WÄRMEDÄMMSTOFFE
5. 1 Mineralwolle nach DIN EN 13162
5. 2 Expandierter Polystyrolschaum nach DIN EN 13163
5. 3 Extrudierter Polystyrolschaum nach DIN EN 13164
5. 4 Polyurethan-Hartschaum nach DIN EN 13165
5. 5 Phenolharz-Hartschaum nach DIN EN 13166
5. 6 Schaumglas nach DIN EN 13167
5. 7 Holzwolleleichtbauplatten nach DIN EN 13168
5. 8 Blähperlith nach DIN EN 13169
5. 9 Expandierter Kork nach DIN EN 13170
5.10 Holzfaserdämmstoff nach DIN EN 13171
6.   HOLZ- UND HOLZWERKSTOFFE
7.   BELÄGE, ABDICHTSTOFFE UND ABDICHTUNGSBAHNEN
7. 1 Fußbodenbeläge
7. 2 Abdichtstoffe (Dichtungsstoffe, Dichtungen und wärmetechnische Trennungen)
7. 3 Dachbahnen, Dachabdichtungsbahnen
8.   SONSTIGE GEBRÄUCHLICHE STOFFE
8. 1 Lose Schüttungen, abgedeckt
8. 2 Fliesen
8. 3 Glas
8. 4 Natursteine
8. 5 Lehmbaustoffe
8. 6 Böden, naturfeucht
8. 7 Keramik und Glasmosaik
8. 8 Metalle
8. 9 Gummi
8.10 Massive Kunststoffe aus DIN 12524
8.11 Gase aus DIN 12524
8.12 Wasser aus DIN 12524
8.13 Dachziegelsteine aus DIN 12524

```

When a material file (*.mtl) is opened (and it has a reference on the first row to a valid index file), the index list file (*.txt) will be opened in the left pane. The two lists use the section numbers (e.g. "1.10") to reference each others. Note that there must be a spacing in order to sort the list correctly ("5.10" comes after "5. 1").

9.2 Default material file

The default material file that is used when HEAT3 starts is the one given on the first row in file "Default_MTL_Filename.txt". It can be changed as follows:

1. Open "Default_MTL_Filename.txt"
2. Write the material file on the first row, e.g.: "DIN 4108-4.mtl"

An example of the "Default_MTL_Filename.txt" would be as follows:

```

DIN 4108-4.mtl
Default.mtl
General.mtl
DIN no cap.MTL

```

(The default material file is here DIN 4108-4.mtl).

10. Batch jobs

10.1 Batch job options

HEAT3 can be started using the parameters given in Table 10.1.

parameter	description	followed by
(file)	first parameter is the input H3P-file name	
s	steady-state analysis	
t	transient analysis	string (stop time e.g. "1d3h")
w	relaxation coefficient (use with the "noopt" parameter)	real number (e.g. "1.93")
x	read temperature field file (will be used for initial temperature field)	string (e.g. "temp.ijk")
y	write output temperature field file (calculated temperature field will be saved to this file)	string (e.g. "temp.ijk")
r	recorder output file name (recorder should be enabled in the h3p input file)	string (e.g. "recfile.rec")
min	minimize HEAT3 when started	
nowait	HEAT3 will by default wait 10 seconds after a batch job to allow the user to interrupt a new batch job. The "nowait" parameter makes HEAT3 continue to the next batch job without waiting.	
noopt	no optimization of the (the relaxation coefficient specified by parameter "w" will be used, if this is missing the one given in the H3P-file will be used)	

Table 10.1: HEAT3 start parameters.

At least on blank space should be put between the parameters. An example is

"HEAT3 cen_case1 s"

This will run a steady-state calculation of cen_case1.h3p and then shut down HEAT3. A log file named **BatchLog.txt** will always be written with the calculated heat flows and the start and end time:

```
CEN_CASE1 S
Calculation started at 10:22:25 AM, 10/3/2005
Set      Q[W]    q[W/m²]    Tmin      Tmax
1        7.9454   8.3636    11.117    15.272
3        9.5435   10.046    11.111    13.339
5       -3.6357   -3.6358    11.124    16.844
7       -23.223   -8.3088    0.0602    0.5505
8       -27.027  -10.306    0.0602    2.2145
9        13.424   13.424    11.298    17.788
11       15.624   15.624    11.294    17.776
14       16.958   16.958    11.292    17.905
15       -0.3293  -3.6584    0.0031    1.3275
16       -0.0294  -0.1707    0.0026    0.011
18       -4.6277  -6.7068    0.0033    2.2324
19       -4.6236  -6.7009    0.0032    2.2177

Heat flow through surfaces of BC type:
2:  46.005 W    2: T=20°C, R=0.2 m²·K/W
3: -59.86 W    3: T=0°C, R=0.05 m²·K/W
4:  13.853 W    4: T=15°C, R=0.2 m²·K/W

Net heat flow through sets = -0.0013 W
Calculation stopped at 10:22:51 AM, CPU time=26s
ICPS=5498870 (iterated cells per second) Iter=304
```


If the file BatchLog.txt already exists, the output results will be appended (written) to the end of the file.

HEAT3 displays a window with the batch job parameters, see Figure 10.1. To interrupt a batch job press the cancel button.

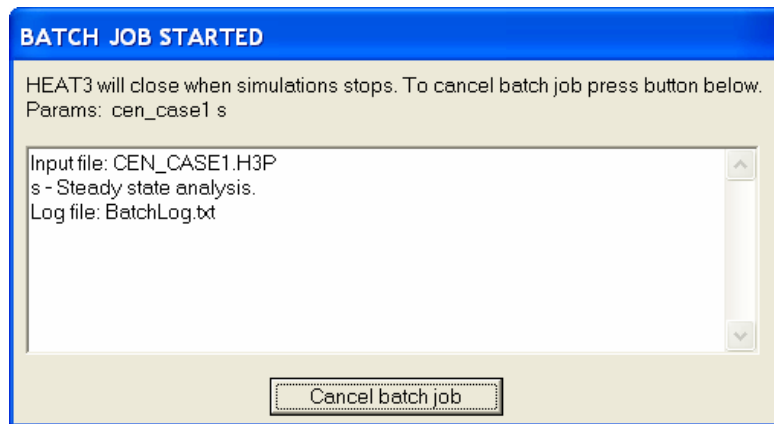


Figure 10.1: Window shown in HEAT3 during batch mode.

10.2 Running multiple batch jobs

Multiple batch jobs can be started using a bat-file. This can be created with a simple editor such as *Notepad* or *WordPad*. The file name should have the extension “bat” (e.g. *mybat.bat*). An example of such a file is shown below.

```
HEAT3 cen_case1 s           //steady-state
HEAT3 ex1 s noopt w 1.99    //steady-state, use fixed relaxation 1.99
HEAT3 ex2 t 1d y tfile.ijk //transient 1 day, writes temperature field
HEAT3 ex2 t 2d x tfile.ijk //transient 2 days, reads temperature field
HEAT3 ex3 t 1d r test       //transient, recorder file test.rec will be saved
HEAT3 ex1 s noopt w 1.93    //steady-state, use fixed relaxation coeff. w=1.93
```

The batch file can be started by clicking on it. A line can be ignored by putting a letter before it, e.g. “xHEAT3 cen_case1 s”.

11. Miscellaneous new features and changes

11.1 Recorder

The chart window for the recorder can now show multiple graph lines in the same chart. Use the buttons *Draw*, *Add*, *Add all* and *Clear* in the Recorder window, see Figure 11.1.

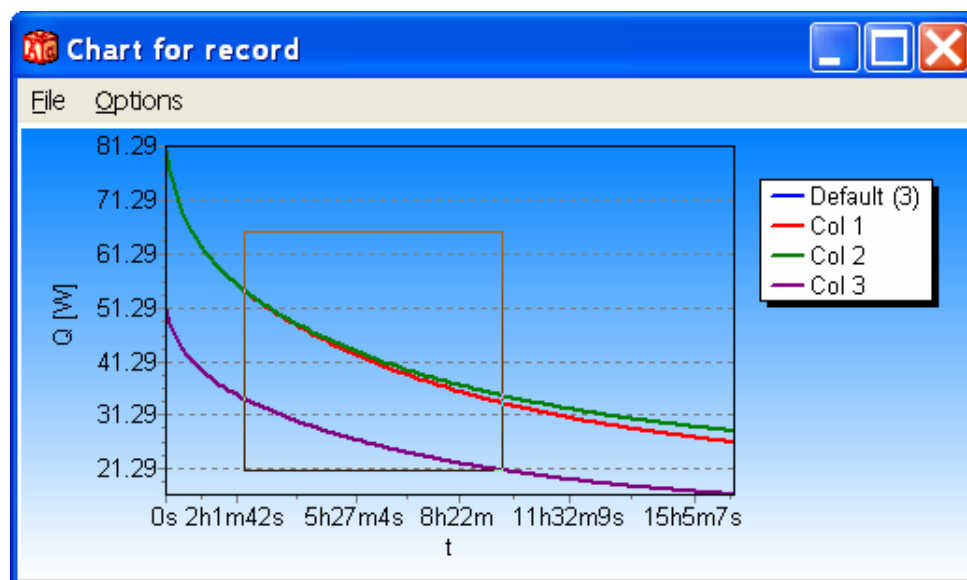
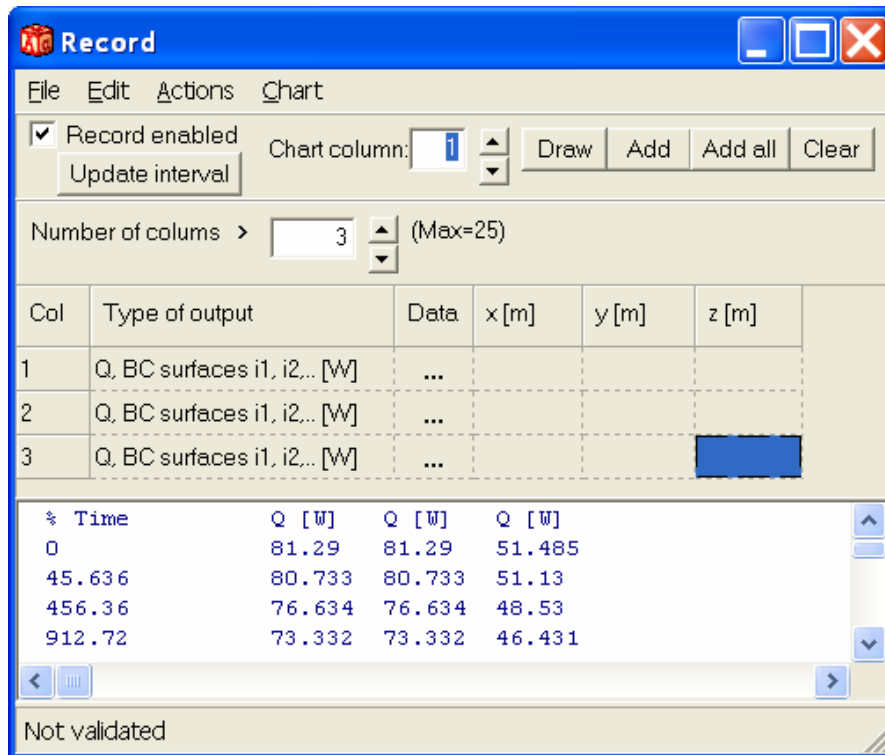


Figure 11.1: Use buttons *Draw*, *Add*, *Add all* and *Clear* to add lines to the chart. A zoom window is shown here.

11.2 Optimization of relaxation coefficient

The relaxation coefficient is now optimized during the calculation which may give considerably shorter calculation times. As an extreme example, the slab problem in the HEAT3 4 manual with 570 000 nodes took 100 seconds to solve with optimization. Without optimization this calculation needed 640 seconds when the default value for the relaxation coefficient of 1.95 was used.

The time for optimized steady-state calculations is lowered by 20-50% for most cases. The optimization is made by default but can be turned off (menu item *Solve/Options for steady-state*), see Figure 11.2.

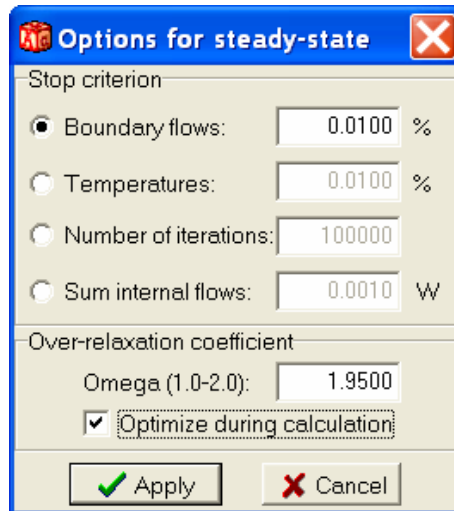


Figure 11.2: Optimization of relaxation coefficient is turned on by default.

11.3 Default stop criterion for steady-state

The default stop criterion for steady-state calculations is now the first one (*Boundary flows*) in Figure 11.2. The sum of all heat flows (positive and negative) entering the boundary surfaces, divided by the sum of the absolute values of all these heat flows, must be less than a given value, see Chapter 5.7 in the HEAT3 4.0 manual.

In HEAT3 4.0, the default one was the last item (*Sum internal flows*). This option will calculate the sum of all internal flows, i.e. the sum of all net flows flowing to each cell.

If the default boundary condition type is non-adiabatic there might be a heat flow through surfaces that have this boundary condition. The first stop criterion for boundary flows does not take these surfaces into account (only explicitly given boundary surfaces are considered). It is better to use another stop criterion in this case. HEAT3 5 will issue a warning for this.

11.4 Enhancements in pre-processor

Figure 11.3 shows the new lay-out for the pre-processor. There is a new tool button *undo zoom* (back to last zoomed window). There is also a new tool to create lines for charting temperatures and heat flows, see Chapter 8.

The pre-processor is now locked after a simulation. This is to avoid unintentional changes (that may lead to that the temperature field is initialized). Many items are disabled in locked mode but the tools for *cut-out boxes* and *temperature lines* are still enabled. To un-lock the pre-processor click on the **Lock** button (lower left).

The drawing will now be centered in the pre-processor when “*Fit in window*” is used.

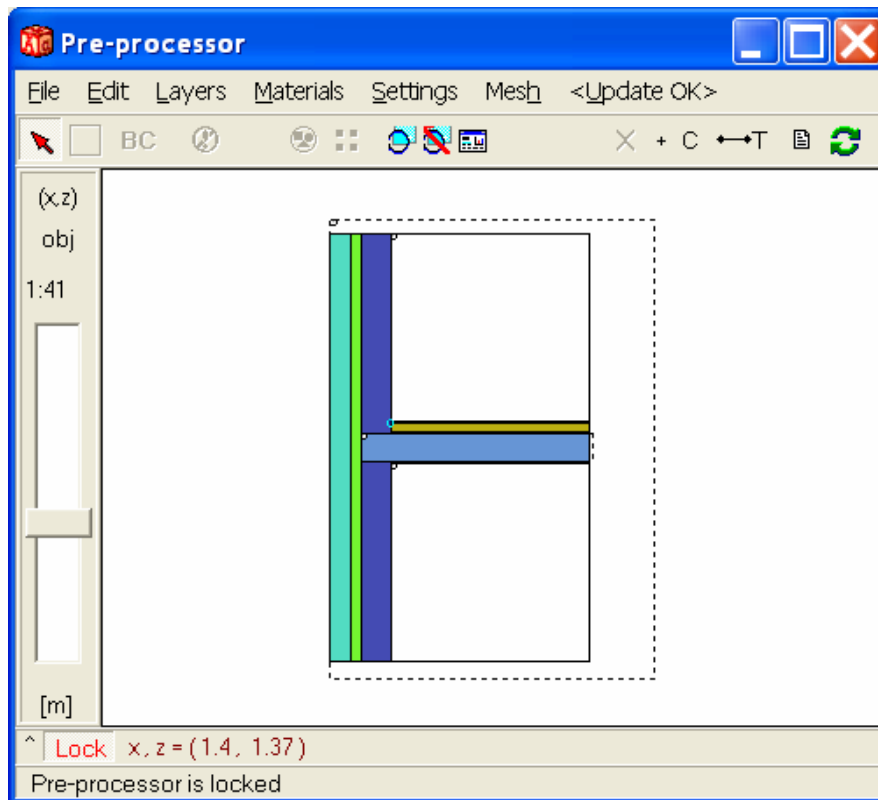


Figure 11.3: New lay-out for pre-processor.

11.5 Saving desktop state

The desktop state with placement and sizes of windows may be saved/read (menu item *Options*) to a file (*.dsk). Most, but not all, windows are included.

Optionally, a default desktop file “HEAT3.DSK” may be read/saved every time HEAT3 is started/closed.