TTLP100 – Exchange-wall in transitory thermics

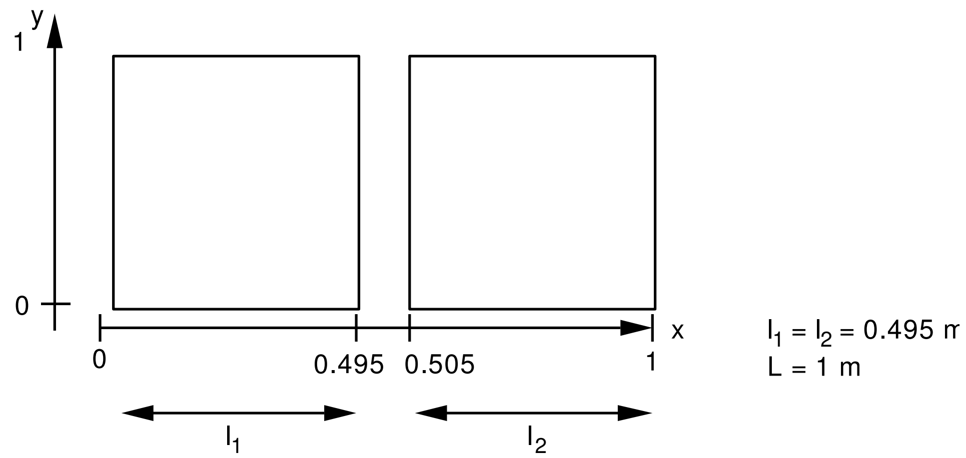
Summary

One calculates the linear transitory answer thermal or not linear of two plates separated by a game in which a transfer of heat is carried out. The problem is 2D but the boundary conditions make that the temperature depends only on the X-coordinate and time. One quickly reaches the stationary state, which is calculable analytically.

The test makes it possible to check the good taking into account of the terms related to the heat transfer between 2 walls.

1 Problem of reference

1.1 Geometry



1.2 Material properties

$\lambda=40\,W/m\,°C$

$\rho C_p=7.3\,10^{-4}\,J/m^3\,°C$ or $\beta=\left|\begin{array}{l}0 \text{ à } 0\,°C\\ 220.10^{-3}\,J/m^3 \text{ à } 300\,°C\end{array}\right.$

To deal with the same problem in nonlinear thermics, an enthalpy is defined β refine whose slope is equal to the specific heat ρC_p

1.3 Boundary conditions and loadings

$T(x=0)=100\,°C=T_0$

$T(x=L)=300\,°C=T_L$

Heat transfer enters the walls located in $x=0.495$ and $x=0.505$, with a coefficient of exchange of $80\,W/m^2\,°C$ ·

1.4 Initial conditions

$T(t=0)=$ T_0 in the plate of left
T_L in the plate of right-hand side

2 Reference solution

2.1 Method of calculating used for the reference solution

The stationary analytical solution is obtained by solving a null Laplacian on each of the two plates of the form $T(x)=ax+b$, the 4 coefficients (2 per plate) are obtained by clarifying the boundary conditions:

$$0. \leq x \leq 0.495 \ : \ T = T_0 + \frac{h(T_L - T_0)}{\lambda + h(l_1 + l_2)} x$$

$$0.505 \leq x \leq 1. \ : \ T = T_L - \frac{h(T_L - T_0)}{\lambda + h(l_1 + l_2)} (L - x)$$

2.2 Results of reference

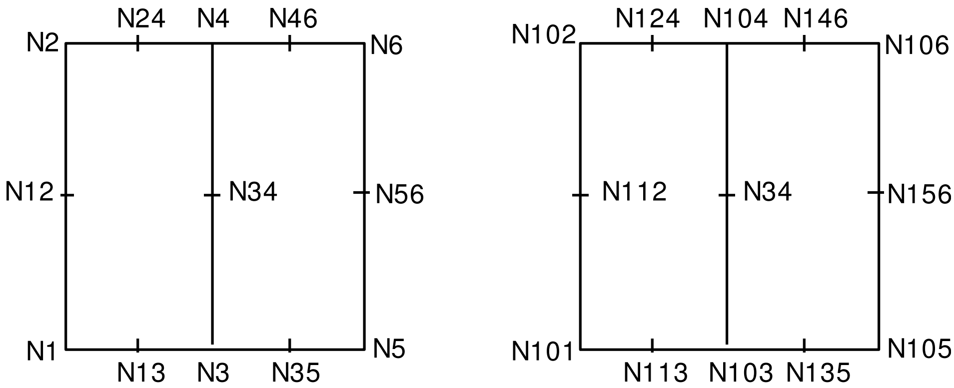
Temperatures on the line $y=0$

2.3 Uncertainty on the solution

Analytical solution.

3 Modeling A

3.1 Characteristics of modeling



The grid is carried out with elements of the type QUAD8.

Is calculated in nonlinear thermics, with $\theta=0.57$.

One makes 50 pas de time of 0 with $5.10^{-2}s$. The results are examined in $t=5.10^{-2}s$.

3.2 Characteristics of the grid

4 QUAD8, 4 SEG3, 26 nodes

3.3 Values tested

Identification	Reference
TEMP node $N3$	133.557026
TEMP node $N5$	166.442953
TEMP node $N101$	233.557047
TEMP node $N103$	266.442953

3.4 Remarks

The solution *Aster* the stationary state reached from $t=4.710^{-2}s$.

4 Modeling B

4.1 Characteristics of modeling

Is calculated in nonlinear thermics, with $\theta=0.57$.

One makes 1 pas de time of 0 with $10^{-9}s$ and 300 pas de time of $10^{-9}s$ with $1.5\,10^{-5}s$

The results are examined in $t=1.5\,10^{-5}s$.

4.2 Characteristics of the grid

4 QUAD8, 4 SEG3, 26 nodes

4.3 Values tested

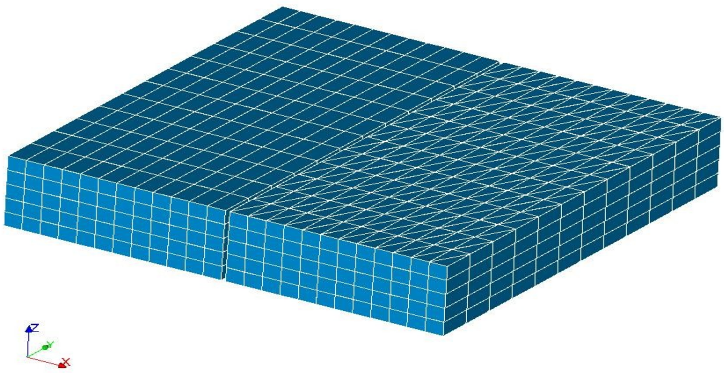
Identification	Reference
TEMP node $N3$	133.557026
TEMP node $N5$	166.442953
TEMP node $N101$	233.557047
TEMP node $N103$	266.442953

4.4 Remarks

The precision required on the results is only of 10^{-3} (instead of 10^{-6} into linear) because one does not have yet, with $t=1.5\,10^{-5}s$, rigorously reached the stationary state.

5 Modeling C

5.1 Characteristics of modeling



Is calculated in nonlinear thermics.

One makes 1 pas de time of 0 with $10^{-9}s$ and 30 pas de time of $10^{-9}s$ with $1.5\,10^{-5}s$. The results are examined in $t=1.45\,10^{-5}s$.

5.2 Characteristics of the grid

720 HEXA8 for the first plate, 1440 PENTA6 for the second.

5.3 Values tested

Identification	Reference
TEMP node $N25$	133.557026
TEMP node $N3$	166.442953
TEMP node $N5$	233.557047
TEMP node $N69$	266.442953

5.4 Remarks

The results are quite constant along axis Z.

6 Summaries of the results

The enormous difference in computing time enters THER_LINEAIRE and THER_NON_LINE be partly explained by the fact that one had to much more finely discretize the steps of time into nonlinear (3000 enters 0 and $1.5\,10^{-5}s$ instead of 50 enter 0 and $5.10^{-2}s$) to ensure the convergence of THER_NON_LINE.