TTLP100 – Exchange-wall in transient thermal

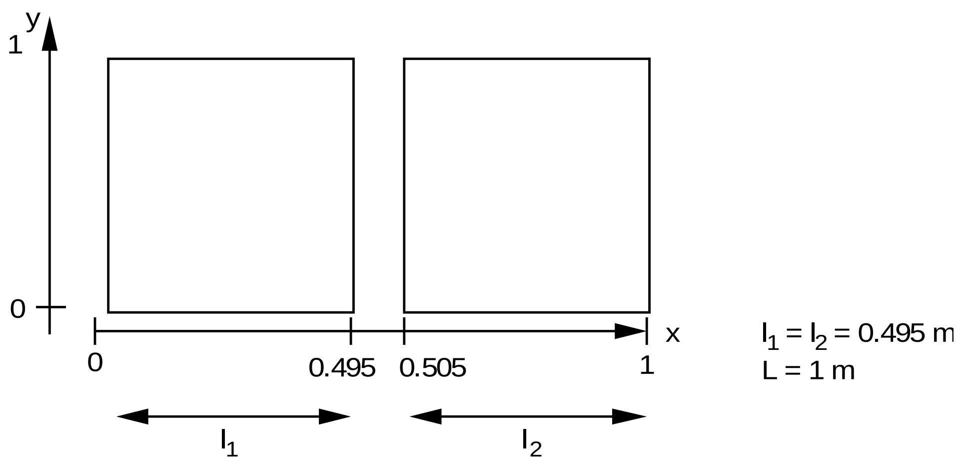
Summarized

One calculates the or not linear response linear transient thermal of two plates separated by a clearance in which a heat transfer 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 steady-state, which is computable 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 thermal, one defines an enthalpy β refines 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 between the walls located in $x = 0.495$ and $x = 0.505$, with a coefficient of heat 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

2 Reference solution

2.1 Method of calculating used for the reference solution

the steady 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:

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

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

2.2 Results of reference

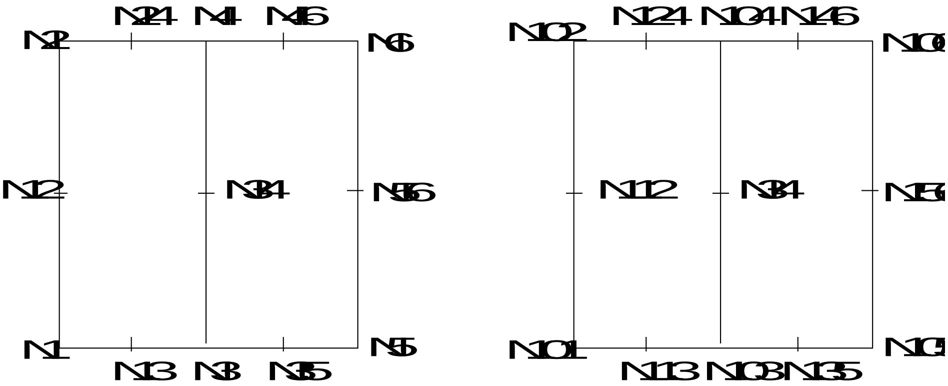
temperatures on line $y=0$

2.3 Uncertainty on the analytical

solution Solution.

3 Modelization A

3.1 Characteristic of the modelization



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

The computation is made in nonlinear thermal, with $\theta=0.57$.

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

3.2 Characteristics of the mesh

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* reached the steady-state from $t=4.710^{-2}s$.

4 Modelization B

4.1 Characteristic of the modelization

The computation is made in nonlinear thermal, with $\theta = 0.57$.

One makes time step 1 0 with $10^{-9} s$ and 300 time step 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 mesh

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 accuracy required on the results are only of 10^{-3} (instead of 10^{-6} into linear) because one, with, rigorously $t = 1.5\,10^{-5} s$ did not reach the steady-state yet.

5 Summaries of the results

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