TTLL303 - Heat transfer in a bar with internal generation of heat

Summarized:

This test is resulting from the validation independent of version 3 in linear transient thermal.

It is about a problem 2D plane represented by only one modelization (plane).

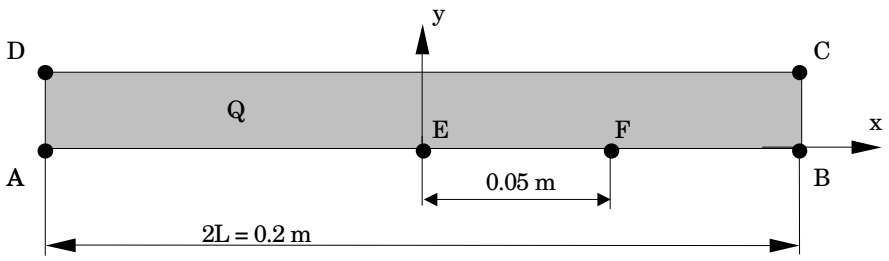
The features tested are the following ones:
- plane thermal element,
- algorithm of transient thermal,
- conditions limiting: heat source.

The interest of the test lies in the taking into account of a heat source.

The results are compared with an analytical solution.

1 Problem of reference

1.1 Geometry



1.2 Properties of the thermal

$\lambda = 100\, W/m°C$ material conductivity

$\rho C_p = 7000\, j/m^3 °C$ voluminal heat

1.3 Boundary conditions and loadings

- internal Heat source $Q = 10^6\, W/m^3$
- $[AB]$ $[CD]$ $\varphi = 0$
- $[BC]$ $[DA]$ $T = 0°C$.

1.4 Initial conditions

$T(t=0) = 0°C$

2 Reference solution

2.1 Method of calculating used for the reference solution

$$T=\frac{Q\,L^2}{2\lambda}\left(1-\left(\frac{x}{L}\right)^2-\frac{32}{\pi}\sum_{i=0}^{\infty}\frac{(-1)^i}{(2\mathrm{i}+1)^3}\cos\left(\frac{2\mathrm{i}+1}{2\mathrm{L}}\pi\right)\exp\left(\frac{-\lambda}{\rho\,c}\left(\frac{2\mathrm{i}+1}{2\mathrm{L}}\pi\right)^2 t\right)\right)$$

the values of reference are obtained with $i=1000$.

2.2 Results of reference

Temperature to the points E and F times $t=0.25$ and $0.5\,s$

2.3 Uncertainty on the analytical

solution Solution.

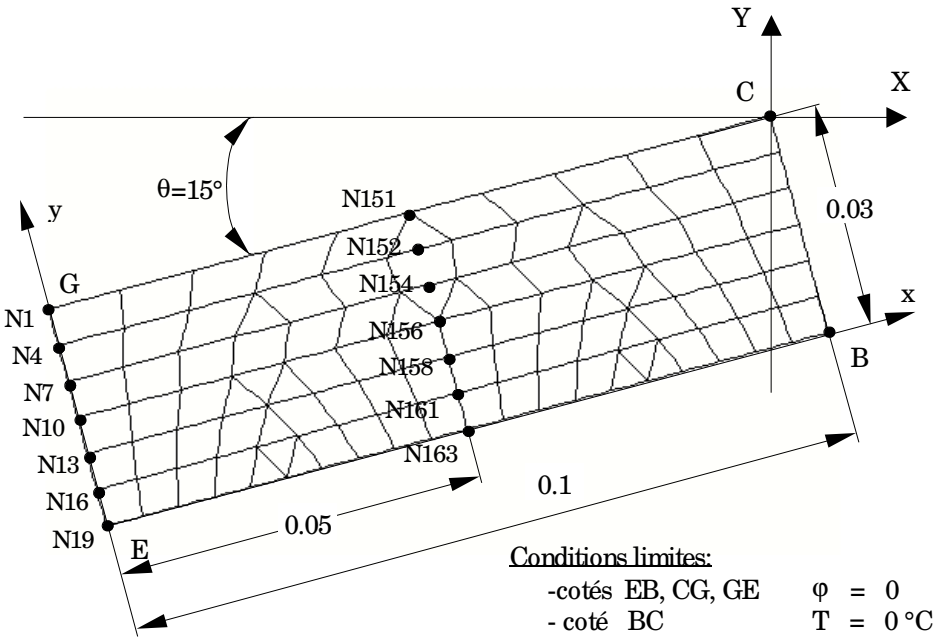
2.4 Bibliographical references

- B.M. Nicolaï, J. of Baerdemaeker, “variable Computation of heat conduction in materials with random thermophysical properties”, Int. J. num. Meth. Engng, flight 36, pp 523-536, 1993.

3 Modelization A

3.1 Characteristic of the modelization

PLANE (TRIA6, QUAD8)



3.2 Characteristic of the mesh

Many nodes:	314
Number of meshes and types:	97 (20 TRIA6, 77QUAD8)

3.3 Remarks

the discretization in time step are the following one:

50 steps for $[0.,0.50]$ are $\Delta t = 1.\mathrm{D}-2$

4 Results of the modelization A

4.1 Values tested

			relative Variation %		Absolute Deviation	
Identification	**Reference**	***Aster***	**difference**	**tolerance**	**difference**	**tolerance**
Temperatures $(°C)$						
$x=0$, $t=0.25\,s$						
N1	28.62	28.58	-0.145	1.00%	-0.042	0.05
N4	28.62	28.58	-0.145	1%	-0.042	0.05
N7	28.62	28.58	-0.145	1%	-0.042	0.05
N10	28.62	28.58	-0.145	1%	-0.042	0.05
N13	28.62	28.58	-0.145	1%	-0.042	0.05
N16	28.62	28.58	-0.145	1%	-0.042	0.05
N19	28.62	28.58	-0.145	1%	-0.042	0.05
$x=0.05$, $t=0.25\,s$						
N151	22.38	22.35	-0.127	1%	-0.028	0.05
N152	22.38	22.35	-0.127	1%	-0.028	0.05
N154	22.38	22.35	-0.127	1%	-0.028	0.05
N156	22.38	22.35	-0.127	1%	-0.028	0.05
N158	22.38	22.35	-0.127	1%	-0.028	0.05
N161	22.38	22.35	-0.127	1%	-0.028	0.05
N163	22.38	22.35	-0.127	1%	-0.028	0.05
$x=0$, $t=0.50\,s$						
N1	41.14	41.11	-0.081	1%	-0.033	0.05
N4	41.14	41.11	-0.080	1%	-0.033	0.05
N7	41.14	41.11	-0.081	1%	-0.033	0.05
N10	41.14	41.11	-0.081	1%	-0.033	0.05
N13	41.14	41.11	-0.081	1%	-0.033	0.05
N16	41.14	41.11	-0.081	1%	-0.033	0.05
N19	41.14	41.11	-0.081	1%	-0.033	0.05
$x=0.05$, $t=0.50$s						
N151	31.24	31.21	-0.091	1%	-0.029	0.05
N152	31.24	31.21	-0.091	1%	-0.029	0.05
N154	31.24	31.21	-0.091	1%	-0.029	0.05
N156	31.24	31.21	-0.091	1%	-0.029	0.05
N158	31.24	31.21	-0.091	1%	-0.029	0.05
N161	31.24	31.21	-0.091	1%	-0.029	0.05
N163	31.24	31.21	-0.091	1%	-0.029	0.05

5 Summary of the results

the got results are satisfactory, the maximum change is of – 0.15%.

The points of observations, located at $x=0.05$ and pertaining to meshes of different types, have the same one result.

This test made it possible to test out of linear transient (modelization PLANE), command AFFE_CHAR_THER_F with operand SOURCE.