TTLP303 - Transfer of heat in an orthotropic plate: imposed temperatures

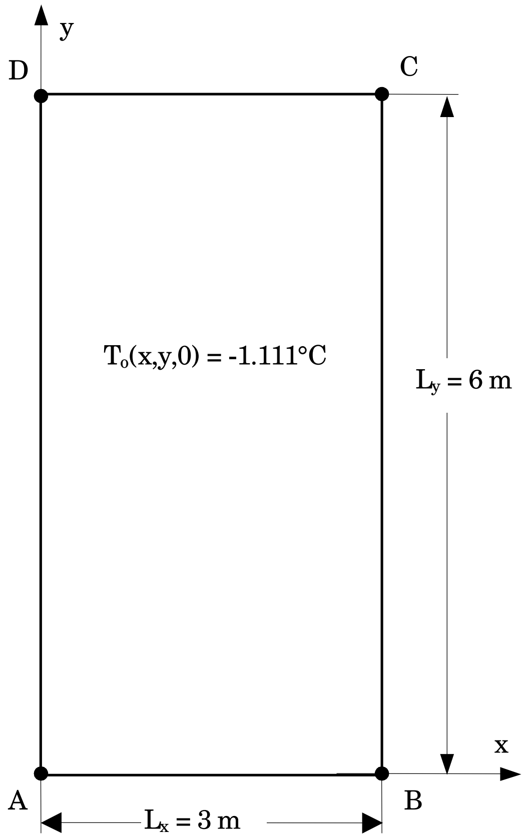
Summary:

This test is resulting from the validation independent of version 3 in thermics.

Analysis:	Linear transitory thermics
Problem:	2D plan
Features tested:	• thermal element hull • thermal element plan • orthotropic material • transitory algorithm of thermics • limiting conditions: imposed temperatures
Interest of the test:	• orthotropic material • analytical solution
Many modelings:	• 1 modeling hull • 1 plane modeling

1 Problem of reference

1.1 Geometry



1.2 Properties of material

$\lambda_x = 1.319\, W/m\,°C$ thermal conductivity along the axis x
$\lambda_y = 0.659\, W/m\,°C$ thermal conductivity along the axis y
$\rho C = 1899.1\, J/m^3\,°C$ voluminal heat

1.3 Boundary conditions and loadings

Contour $ABCD$: $T = -17.778\,°C$

1.4 Initial conditions

$T_0(t=0) = -1.111\,°C$

2 Reference solution

2.1 Method of calculating used for the reference solution

$$T(x,y,t)=\sum_{n=1}^{\infty}\sum_{j=1}^{\infty} A_n \sin\frac{n\pi x}{L_x}\sin\frac{j\pi y}{L_y}\exp\left[-\left(\frac{\lambda_x n^2\pi^2}{L_x^2}+\frac{\lambda_y j^2\pi^2}{L_y^2}\right)t/\rho c\right]$$

where $A_n=\left[\frac{4(T_i)}{\pi^2 jn}[(-1)^n-1][(-1)^j-1]-32\right]\frac{5}{9}$ $T_i=\frac{5}{9}T_0+32$

Temperature in $°C$ with $t=4320\mathrm{s}$

3.0	-17.7778	-17.5742	-17.3905	-17.2448	-17.1515	-17.1189
2.7	-17.7778	-17.5764	-17.3948	-17.2507	-17.1581	-17.1262
2.4	-17.7778	-17.5832	-17.4077	-17.2684	-17.1790	-17.1482
2.1	-17.7778	-17.5945	-17.4291	-17.2979	-17.2137	-17.1847
1.8	-17.7778	-17.6102	-17.4590	-17.3391	-17.2620	-17.2355
1.5	-17.7778	-17.6302	-17.4970	-17.3914	-17.3235	-17.3002
1.2	-17.7778	-17.6542	-17.5426	-17.4541	-17.3973	-17.3777
0.9	-17.7778	-17.6816	-17.5949	-17.5261	-17.4819	-17.4667
0.6	-17.7778	-17.7120	-17.6526	-17.6056	-17.5753	-17.5649
0.3	-17.7778	-17.7444	-17.7142	-17.6903	-17.6749	-17.6696
0.0	-17.7778	-17.7778	-17.7778	-17.7778	-17.7778	-17.7778
$Y\uparrow$ $X\rightarrow$	0.0	0.3	0.6	0.9	1.2	1.5

The values of reference are obtained with $n=j=1000$

2.2 Results of reference

$t=4320\mathrm{s}(1.2\mathrm{hr})$: temperature at the following points:

- in $x=0.6$: for $y=0.6, 1.5, 2.4, 3.0$
- in $x=1.5$: for $y=0.6, 1.5, 2.4, 3.0$

2.3 Uncertainty on the solution

Analytical solution.

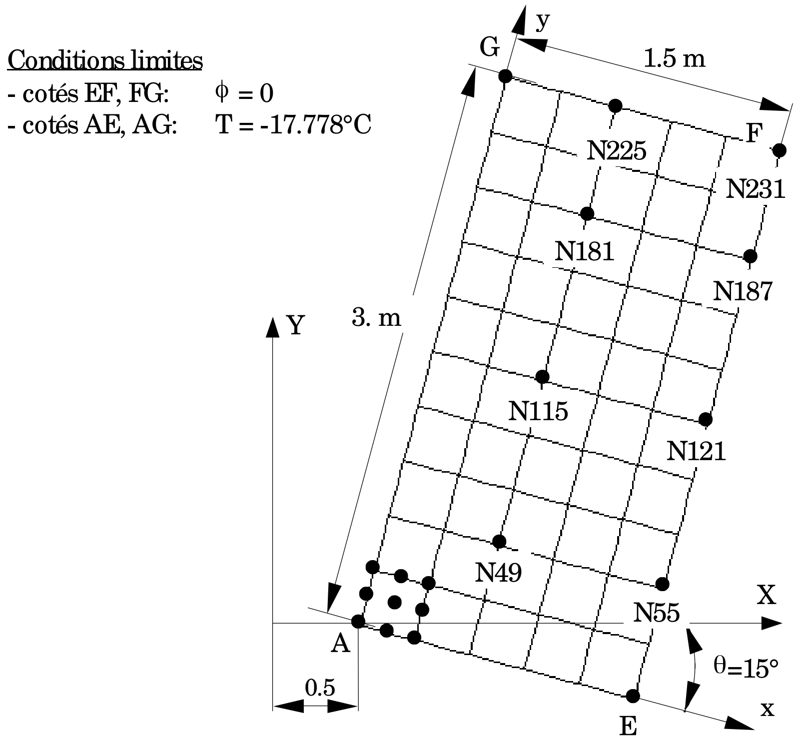
2.4 Bibliographical references

1. J.C. Bruch Jr., G. Zyroloski, 'Transient two-dimensional heat conduction problems solved by the finite element method', Int. J. num. Meth. Engng, flight 8, n°3, pp 481-494, 1974.

3 Modeling C

3.1 Characteristics of modeling

PLAN (QUAD9)



3.2 Characteristics of the grid

Many nodes:	231
Many meshs and types:	50 QUAD9

3.3 Remarks

The discretization in step of time is the following one:

240 pas for $[0., 4320.D0]$ that is to say $\Delta t = 18.D0$

4 Results of modeling C

4.1 Values tested

			Relative variation %		Absolute deviation	
Identification	**Reference**	***Aster***	**difference**	**tolerance**	**difference**	**tolerance**
Temperature in $°C$						
$x=0.6$						
$N49(y=0.6)$	-17.6526	-17.6515	-0,006	1%	0,001	0.05
$N115(y=1.5)$	-17.4970	-17.4942	-0,016	1%	0,003	0.05
$N181(y=2.4)$	-17.4077	-17.4040	-0,021	1%	0,004	0.05
$N225(y=3.0)$	-17.3905	-17.3867	-0,022	1%	0,004	0.05
$x=1.5$						
$T(y=0.6)$	-17.5649	-17.5627	-0,012	1%	0,002	0.05
$T(y=1.5)$	-17.3002	-17.2952	-0,029	1%	0,005	0.05
$T(y=2.4)$	-17.1482	-17.1418	-0,037	1%	0,006	0.06
$T(y=3.0)$	-17.1189	-17.1123	-0,039	1%	0,007	0.05

5 Summary of the results

Modeling PLAN, carried out with meshs QUAD9, gives satisfactory results, the maximum change obtained is of 0,039%.