TTLP302 - Heat transfer in a Plan field with geometrical singularity

Summary:

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

It is about a problem $2D$ plan represented by two modelings, one planes, the other voluminal one.

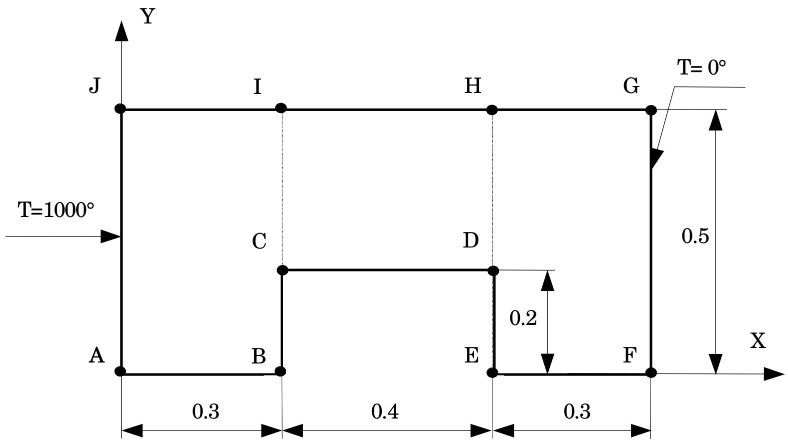
The features tested are the following ones:

- thermal element plan,
- voluminal thermal element,
- transitory algorithm of thermics,
- geometrical singularity,
- limiting conditions: imposed temperature.

The interest of the test, besides the fact that it is an industrial case, lies in the taking into account of a geometrical singularity in transitory thermal analysis.

1 Problem of reference

1.1 Geometry



1.2 Properties of material

$\lambda = 1.\ W/m\,°C$ Thermal conductivity

$\rho C_P = 1.\ J/m3\,°C$ Voluminal heat

1.3 Boundary conditions and loadings

- $[AJ]$ imposed temperature $T = 1000\,°C$,
- $[FG]$ imposed temperature $T = 0\,°C$,
- others with dimensions $\varphi = 0.$

1.4 Initial conditions

$$T(x, y, 0) = erfc\left(\frac{x}{2\sqrt{t}}\right) \quad \text{for } t = 0.0005\,s$$

2 Reference solution

2.1 Method of calculating used for the reference solution

The reference solution is a digital solution obtained by the finite element method [bib2] quoted in the reference [bib1]. This solution is based on a network of 168 square elements of $0.05\mathrm{m}$ of dimensioned, with 200 pas de time ($\Delta t=0.0005\,s$).

2.2 Results of reference

Temperature at the points $B\,C\,D\,E\,H$ and I at the moment $t=0.1\mathrm{s}$

2.3 Uncertainty on the solution

Unknown factor.

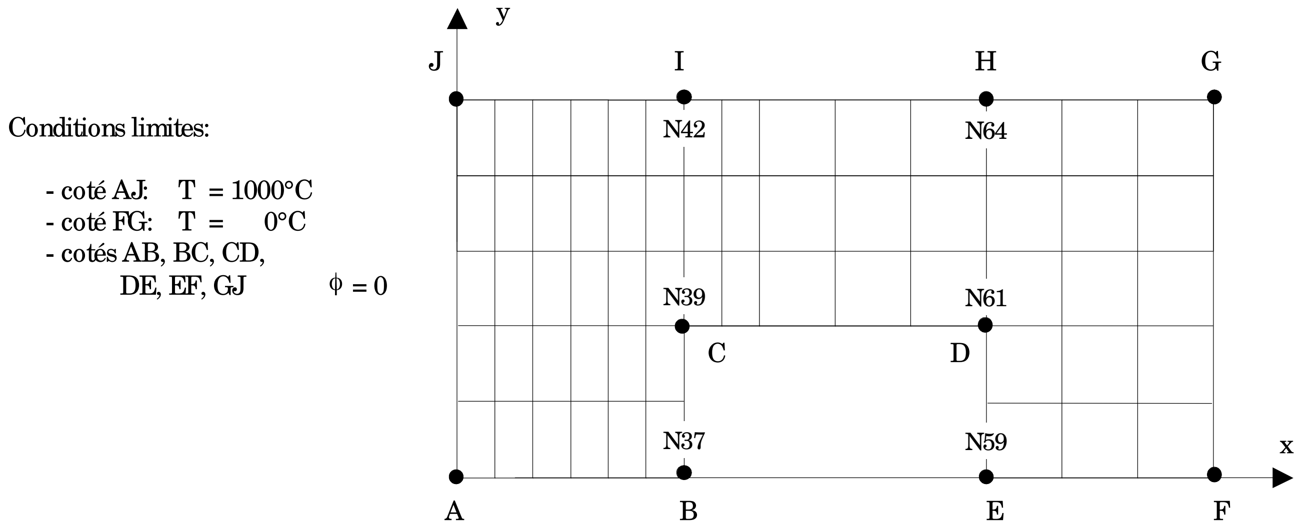
2.4 Bibliographical references

- 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.
- G.E. Beautiful, “with method for treating boundary singularities in time-dependent problems” TR/8, Dept. of Math., Brunel Univ. Uxbridge, Middlesex, 19 pp., 1972.

3 Modeling A

3.1 Characteristics of modeling

PLAN (QUAD4)



3.2 Characteristics of the grid

Many nodes:	82
Many meshs and types:	60 QUAD4

3.3 Remarks

The discretization in step of time is the following one:

10 pas	for $[0., 1.D-4]$	that is to say $\Delta t=1.D-5$
9 pas	for $[1.D-4, 1.D-3]$	that is to say $\Delta t=1.D-4$
9 pas	for $[1.D-3, 1.D-2]$	that is to say $\Delta t=1.D-3$
9 pas	for $[1.D-2, 1.D-1]$	that is to say $\Delta t=1.D-2$

3.4 Sizes tested and results

Identification	Type of Reference	Reference	Tolerance
Temperature $(°C)$			
$t=0.1\,s$			
Points			
$B(N37)$	SOURCE_EXTERNE	787.	2%
$C(N39)$	SOURCE_EXTERNE	634.	2%
$D(N61)$	SOURCE_EXTERNE	86.	2%
$E(N59)$	SOURCE_EXTERNE	28.	2%
$H(N64)$	SOURCE_EXTERNE	119.	2%

$I(N42)$	SOURCE_EXTERNE	538.	2%

4 Summary of the results

Modeling carried out (PLAN with meshs QUAD4) give satisfactory results. The maximum change is of -0.73% , and it is located on the smallest value of reference.

The taking into account of the initial condition of type $erfc\left(\frac{x}{2\sqrt{t}}\right)$ was carried out correctly. It required the use of the order CREA_CHAMP allowing to define an initial field of temperature of each node of the model.