TTLP302 - Heat transfer in a Plane field with geometrical singularity

Abstract:

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

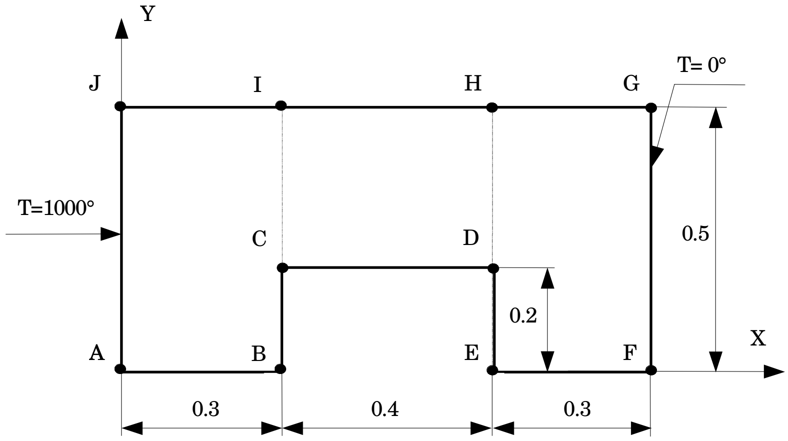
It is about a plane $2D$ problem represented by two modelizations, one planes, the other voluminal one.

The features tested are the following ones:
- plane thermal element,
- voluminal thermal element,
- algorithm of transient thermal,
- 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 the thermal

$\lambda = 1. W/m°C$ material 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 numerical 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 $0.05\mathrm{m}$ dimensioned, with 200 time step ($\Delta t=0.0005\,s$).

2.2 Results of reference

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

2.3 Uncertainty on the Unknown

solution.

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, "A method for treating boundary singularities in time-dependant problems" TR/8, Dept. of Math., Brunel Univ. Uxbridge, Middlesex, 19 pp., 1972.

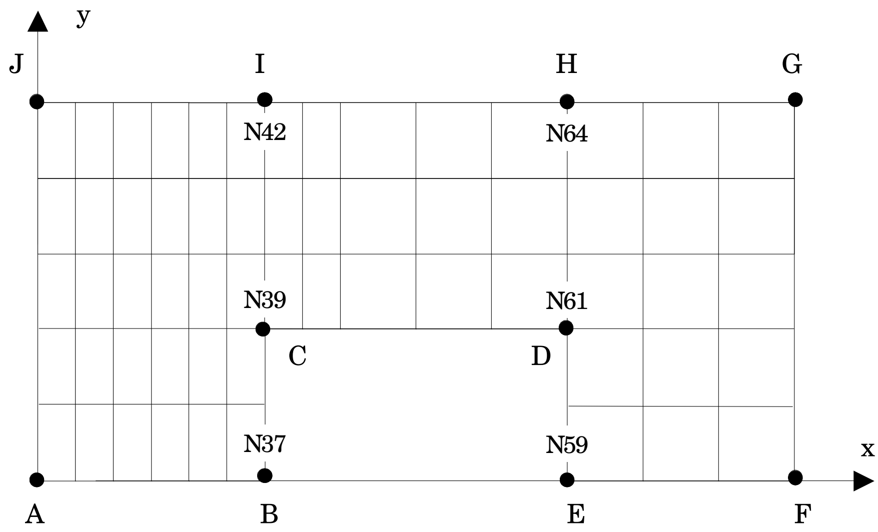
3 Modelization A

3.1 Characteristic of the modelization

PLANE (QUAD4)

Conditions limites:

- coté AJ: T = 1000°C
- coté FG: T = 0°C
- cotés AB, BC, CD, DE, EF, GJ $\varphi = 0$



3.2 Characteristic of the mesh

Many nodes:	82
Number of meshes and types:	60 `QUAD4`

3.3 Remarks

the discretization in time step are the following one:

10 steps	for $[0., 1.D-4]$	either	$\Delta t=1.D-5$
9 steps	for $[1.D-4, 1.D-3]$	or	$\Delta t=1.D-4$
9 steps	for $[1.D-3, 1.D-2]$	or	$\Delta t=1.D-3$
9 steps	for $[1.D-2, 1.D-1]$	or	$\Delta t=1.D-2$

3.4 Quantities tested and Standard

Identification	results 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

The modelization carried out (PLANE with meshes 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 the type $erfc\left(\frac{x}{2\sqrt{t}}\right)$ was carried out correctly. It required use of the command CREA_CHAMP making it possible to define an initial field of temperature of each node of the model.