TTLP301 - Heat transfer in a perforated plate

Summarized:

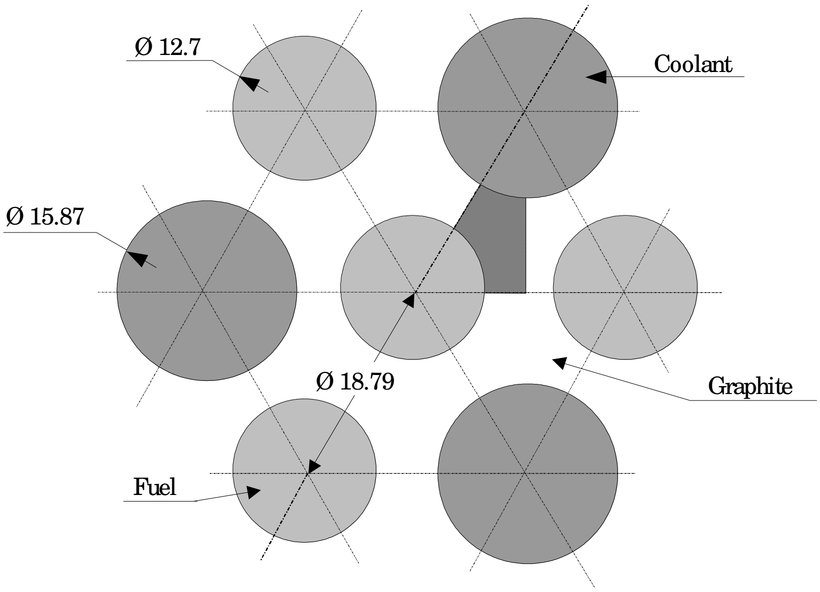
This test, industrialist, are resulting from the validation independent of version 3 in linear transient thermal.

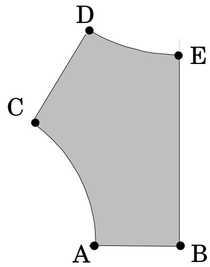
It is about a problem 2D plane represented by two modelizations, one planes, the other voluminal one.

The features tested are the following ones:
- plane thermal element,
- voluminal thermal element,
- algorithm of transient thermal,
- boundary conditions of exchange and flux.

1 Problem of reference

1.1 Geometry





1.2 Properties of the thermal

$\lambda = 0.1\ W/cm\,°C$ material Conductivity

$\rho C_P = 1.0\ J/cm^3\,°C$ voluminal Heat

1.3 Boundary conditions and loadings

- $[ED]$ Convection coefficient $h = 1\ W/cm^2\,°C$ $T_{ext} = 0\,°C$,
- $[AC]$ Density flux $q = 1\ W/cm^2$
- $[AB]$ $[BE]$, $[DC]$ $\varphi = 0.$

1.4 Initial conditions

$T(t=0) = 0$

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. This solution is based on a linear triangular network presented below. Computations were carried out by considering an increment of time $\Delta t=0.01\,s$

2.2 Results of reference

Temperature to the point C for $t=0.1\,,0.2,\ldots,0.9\,,1.0\,,1.1\,,1.2\,s$

2.3 bibliographical References

• J. Donea, "One the accuracy of finite element solutions to the transient heat-conduction equation", Int. J. num. Meth. Engng, flight 8, n°1, pp 103-110, 1974

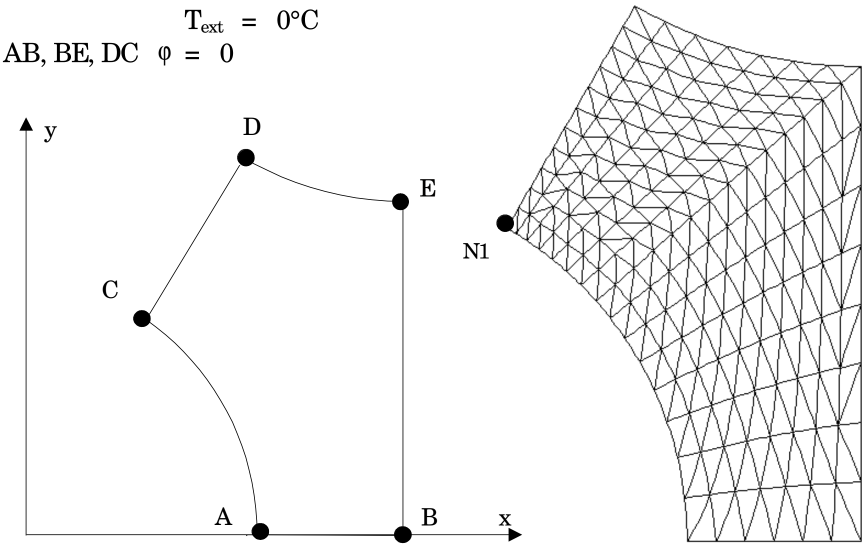
3 Modelization A

3.1 Characteristic of the modelization

PLANE (TRIA6)

Conditions limites:

- coté AC $q = 1$ W/cm²
- coté ED $h = 1$ W/cm² °C
  $T_{ext} = 0$°C
- cotés AB, BE, DC $\varphi = 0$



3.2 Characteristic of the mesh

Many nodes:	718
Number of meshes and types:	TRIA6: 335 (SEG3: 22)

3.3 Remarks

Condition limiting, Flux $\varphi=0.$, not modelled (implicit).

The discretization in time step is the following one:

10 steps	for $[0., 0.2]$	either	$\Delta t=2.D-2$
10 steps	for $[0.2, 12.]$	or	$\Delta t=1.D-1$

4 Results of the modelization A

4.1 Values tested

Identification	Reference	*Aster*	% difference	Tolerance
Node Time (S)	$T(°C)$	$T(°C)$		
n1 0.1	1.045	1.0664	2.05%	2%
” 0.2	1.447	1.4515	0.31%	2%
“ 0.3	1.742	1.7480	0.35%	2%
” 0.4	1.982	1.9847	0.14%	2%
“ 0.5	2.189	2.1929	0.18%	2%
” 0.6	2.373	2.3757	0.11%	2%
“ 0.7	2.541	2.5451	0.16%	2%
” 0.8	2.698	2.7010	0.11%	2%
“ 0.9	2.846	2.8491	0.11%	2%
” 1.0	2.986	2.9889	0.10%	2%
“ 1.1	3.120	3.1232	0.10%	2%
” 1.2	3.248	3.2517	0.11%	2%

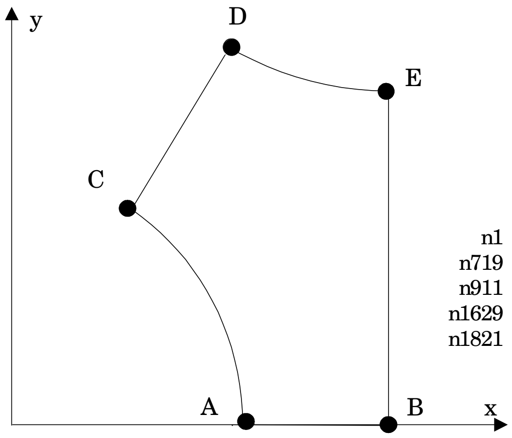
5 Modelization B

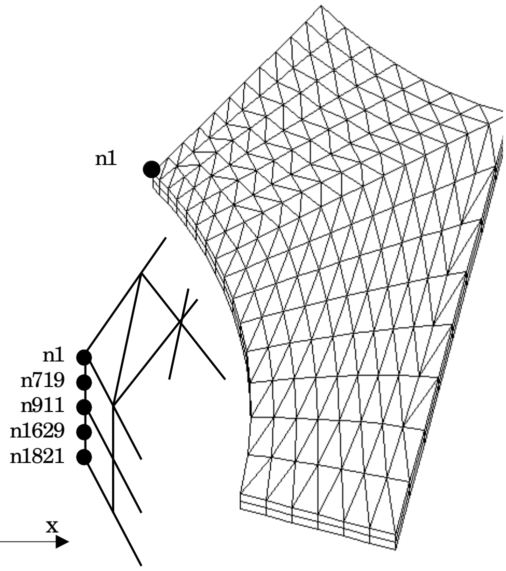
5.1 Characteristic of the modelization

3D (PENTA15)

Conditions limites:

- coté AC q = 1 W/cm²
- coté ED h = 1 W/cm² °C
  T_{ext} = 0°C
- cotés AB, BE, DC φ = 0





5.2 Characteristic of the mesh

Many nodes:	2538
Number of meshes and types:	PENTA15: 670 (QUAD8: 44)

5.3 Remarks

implicit limiting $\varphi=0.$ Condition: not modelled.
The discretization in time step is the following one:

10 steps	for $[0.,0.2]$	either	$\Delta t=2.D-2$
10 steps	for $[0.2,12.]$	or	$\Delta t=1.D-1$

6 Results of the modelization B

6.1 Values tested

Identification	Reference	*Aster*	% difference	Tolerance
Node Time (S)	T (°C)	T (°C)		
n1 0.1	1.045	1.0665	2.05%	2%
“ 0.2	1.447	1.4514	0.30%	2%
” 0.3	1.742	1.7480	0.35%	2%
“ 0.4	1.982	1.9847	0.14%	2%
” 0.5	2.189	2.1929	0.18%	2%
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6.2 Remarks

Difference between the values to the nodes $n1, n719, n911, n1629, n1821$ about $1.e-8$.

7 Summary of the results

the two modelizations give results whose only one value exceeds the tolerance fixed initially. The maximum change is equal to 2.05%, and is thus not very higher than the built-in tolerance (2%). it is located on the smallest value of temperature and for weakest time the T (starting of the problem).

The two modelizations, PLANE (TRIA6) and 3D (PENTA15) gives the same results, which is normal since the mesh and the degree of interpolation are identical.

A finer mesh in the zone of the node $N1$ should improve quality of the results which are regarded as acceptable taking into account the modelizations carried out.