

TPLP01 - Field in L with geometrical singularity

Summary:

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

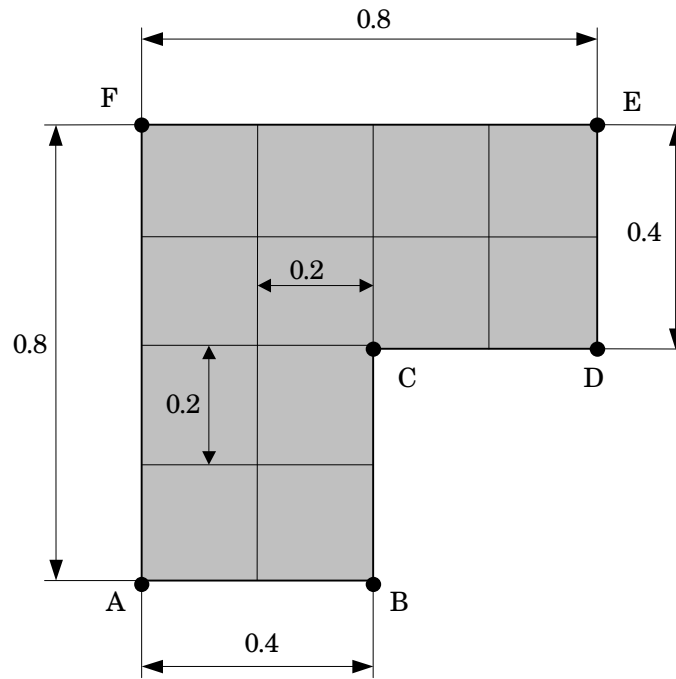
It is about a problem 2D plan presenting two modelings, one planes, the second voluminal one.

The objective is to validate, in the presence of a geometrical singularity, the thermal elements plans and 3D with for boundary condition an imposed temperature.

The results are compared with those provided by VPCS.

1 Problem of reference

1.1 Geometry



Dimensions in meters

1.2 Properties of material

$\lambda = 1. W/m. ^\circ C$ thermal conductivity

1.3 Boundary conditions and loadings

- side $[AF]$ Imposed temperature $T_p = 10^\circ C$,
- side $[DE]$ Imposed temperature $T_p = 0^\circ C$,
- side $[AB], [BC], [CD], [EF]$, $flux = 0$.

1.4 Initial conditions

Without object.

2 Reference solution

2.1 Method of calculating used for the reference solution

The reference solution is that given in card TPLP01/89 of guide VPCS.

2.2 Results of reference

Temperature at the points of a squaring of with dimensions $0.2\text{m} \times 0.2\text{m}$.

2.3 Uncertainty on the solution

Analytical solution.

2.4 References

- [1] Guide of validation of the software packages of structural analysis. French company of the Mechanics, AFNOR 1990 ISBN 2-12-486611-7
- [2] G.T. Symm-, National Physical Laboratory Division of Numerical Analysis and Computing, treatment of singularities in solution of Laplace' S equation by integral year equation method, NPL Carryforward NAC 31, January 1973.

3 Modeling A

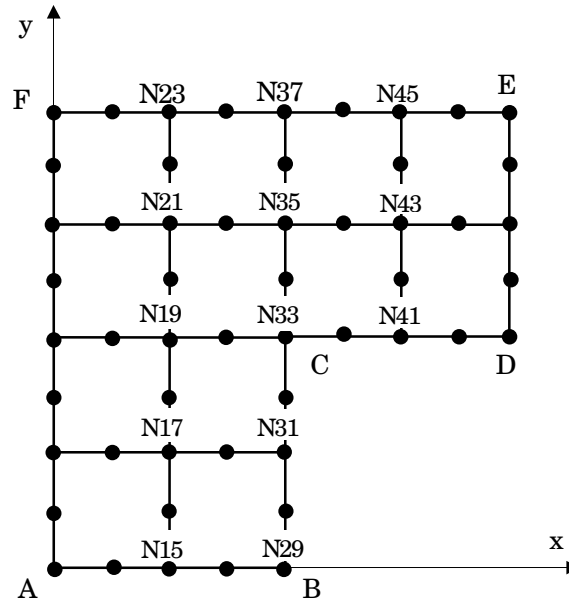
3.1 Characteristics of modeling

PLAN (QUAD8)

Conditions limites:

- coté AF:
- coté DE:
- cotés AB, BC, CD, EF:

$T=10^{\circ}\text{C}$
 $T=0^{\circ}\text{C}$
 $\phi=0$



3.2 Characteristics of the grid

Many nodes: 53
Many meshes and types: 12 QUAD8

3.3 Sizes tested and results

| Identification | Reference | tolerance |
|------------------------------------|-----------|-----------|
| Temperature ($^{\circ}\text{C}$) | | |
| $x=0.2 y=0.0(N15)$ | 9,316 | 1% |
| $y=0.2(N17)$ | 9,001 | 1% |
| $y=0.4(N19)$ | 8,514 | 1% |
| $y=0.6(N21)$ | 8,018 | 1% |
| $y=0.8(N23)$ | 7,869 | 1% |
| $x=0.4 y=0.0(N29)$ | 9,009 | 1% |
| $y=0.2(N31)$ | 8,640 | 1% |
| $y=0.4(N33)$ | 6,667 | 1% |
| $y=0.6(N35)$ | 5,680 | 1% |
| $y=0.8(N37)$ | 5,495 | 1% |
| $x=0.6 y=0.4(N41)$ | 2,972 | 1% |
| $y=0.6(N43)$ | 2,881 | 1% |
| $y=0.8(N45)$ | 2,816 | 1% |

4 Modeling B

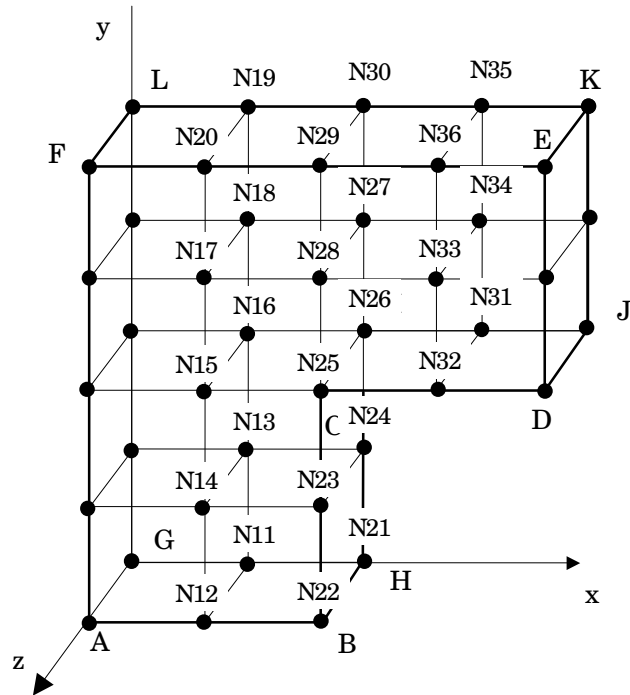
4.1 Characteristics of modeling

3D (HEXA8)

Conditions limites:

- face AGLF: $T=10^{\circ}\text{C}$
- face DJKE: $T=0^{\circ}\text{C}$
- faces ABHG, BHIC: $\phi=0$
- faces CDJI, FEKL: $\phi=0$

Epaisseur = 0.2 m



4.2 Characteristics of the grid

Many nodes: 42
Many meshes and types: 12 HEXA8

4.3 Sizes tested and results

| Identification | Reference | tolerance |
|------------------------------------|-----------|-----------|
| Temperature ($^{\circ}\text{C}$) | | |
| $x=0.2 y=0.0$ (N11) | 9,316 | 1% |
| (N12) | 9,316 | 1% |
| $y=0.2$ (N13) | 9,001 | 1% |
| (N14) | 9,001 | 1% |
| $y=0.4$ (N15) | 8,514 | 1% |
| (N16) | 8,514 | 1% |
| $y=0.6$ (N17) | 8,018 | 1% |
| (N18) | 8,018 | 1% |
| $y=0.8$ (N19) | 7,869 | 1% |
| (N20) | 7,869 | 1% |
| $x=0.4 y=0.0$ (N21) | 9,009 | 1% |
| (N22) | 9,009 | 1% |
| $y=0.2$ (N23) | 8,640 | 1% |
| (N24) | 8,640 | 1% |

| | | |
|-----------------------|-------|----|
| $y=0.4$ (N25) | 6,667 | 1% |
| (N26) | 6,667 | 1% |
| $y=0.6$ (N27) | 5,680 | 1% |
| (N28) | 5,680 | 1% |
| $y=0.8$ (N29) | 5,495 | 1% |
| (N30) | 5,495 | 1% |
| $x=0.6$ $y=0.4$ (N31) | 2,972 | 1% |
| (N32) | 2,972 | 1% |
| $y=0.6$ (N33) | 2,881 | 1% |
| (N34) | 2,881 | 1% |
| $y=0.8$ (N35) | 2,816 | 1% |
| (N36) | 2,816 | 1% |

5 Summary of the results

Two modelings give results whose certain values exceed the tolerance fixed initially (1%):

- for modeling A (PLAN with meshes QUAD8), the maximum change is of 1.19% (going beyond for only one value out of the 13 tested),
- for modeling B (3D with meshes HEXA8), the maximum change is of 2.7% (going beyond for two values out of 26 tested).

The modeling of the geometrical singularity (presence of an important heat gradient close to the singularity) is represented better with quadratic elements (modeling A).

For two modelings, the precision should be improved by using a finer grid (more important refinement in the zone of the geometrical singularity).

The results are regarded as acceptable taking into account modelings carried out.