TPNL300 - Unidimensional transfer of heat with radiation

Summary:

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

It is about a linear problem 1D represented by two modelings, one planes, the other voluminal one.

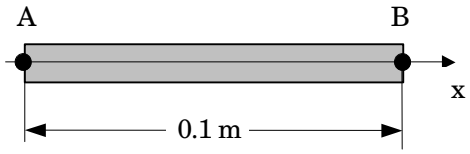
The features tested are the following ones:
- thermal element plan,
- voluminal thermal element,
- limiting conditions: (imposed temperatures, radiation).

The interest of the test lies in the taking into account of the radiation.

The results are compared with those provided by NAFEMS.

1 Problem of reference

1.1 Geometry



1.2 Properties of material

$\lambda = 55.6\, W/m\,°C$ Thermal conductivity
$c = 460.\, J/kg\,°C$ Specific heat
$\rho = 7850.\, kg/m^3$ Density

1.3 Boundary conditions and loadings

- temperature imposed on the point A : $T_A = 726.85\,°C$,
- exchange by radiation at the point B :
  - outside temperature $T_e = 26.85\,°C$,
  - $\varepsilon = 0.98$ emissivity,
  - $\sigma = 5.67.10^{-8}\, W/m^2 K^4$ (constant of Stefan-Boltzmann).

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 the card “TEST n°2” of the tests of reference published by NAFEMS.

2.2 Results of reference

Temperature at the point B : $T=653.85°C$

2.3 Uncertainty on the solution

Nonavailable on card NAFEMS.

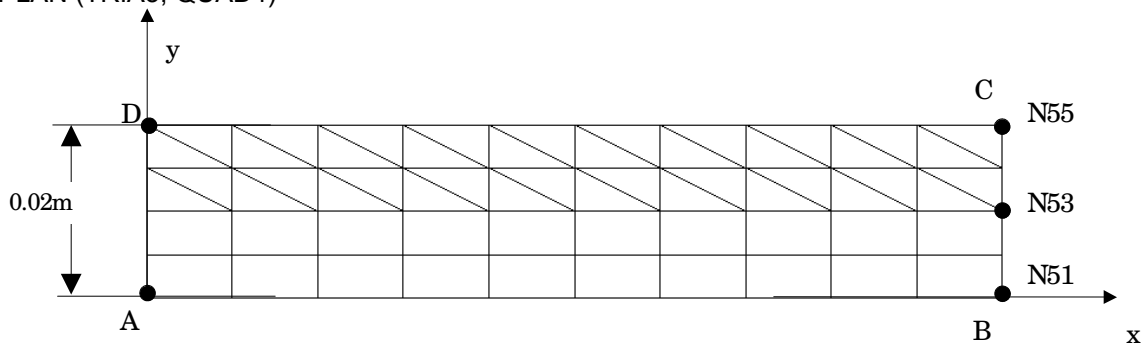
2.4 References bibliographical

- NAFEMS (the National Agency for Finite Element Methods Standard and (the U.K.)): “Standard The NAFEMS Benchmarcks”, TNSB rév 3, October 1990.

3 Modeling A

3.1 Characteristics of modeling

PLAN (TRIA3, QUAD4)



Conditions aux limites:

- Coté AD: T = 726.85°C
- Cotés AB, CD: $\phi = 0$
- Coté BC: T_{ext}=26.85°C
  $\varepsilon = 0.98$

3.2 Characteristics of the grid

Many nodes:	55
Many meshs and types:	60: (20 QUAD4, 40 TRIA3)

4 Results of modeling A

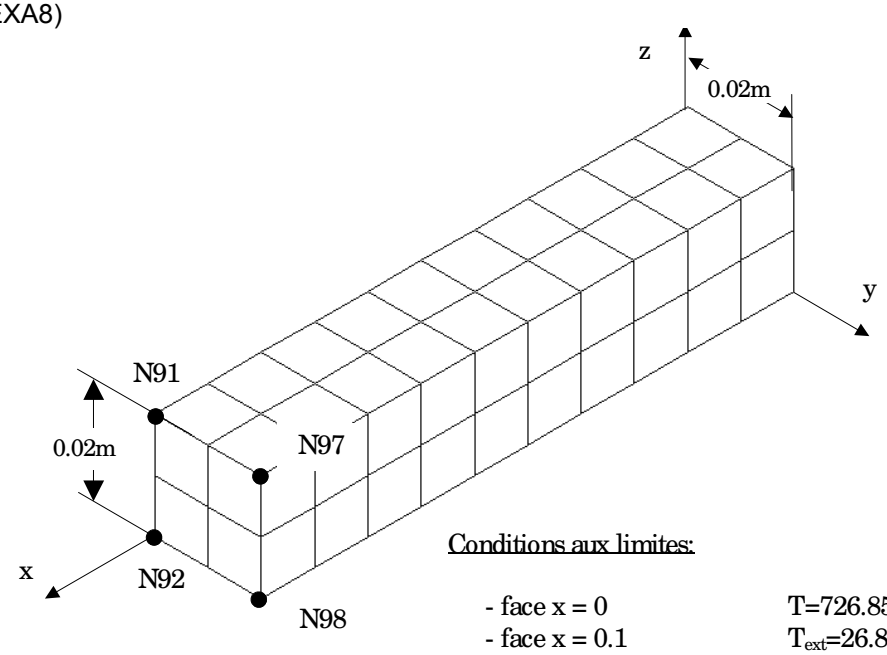
4.1 Values tested

Identification	Reference	*Aster*	% difference	tolerance
Temperature at the point B in °C				
N51	653.85	653.87	0,003	2%
N53	653.85	653.87	0,003	2%
N55	653.85	653.87	0,003	2%

5 Modeling B

5.1 Characteristics of modeling

3D (HEXA8)



Conditions aux limites:

- face x = 0	T=726.85°C
- face x = 0.1	T_{ext}=26.85°C
	ε = 0.98
- autres faces	ϕ = 0

5.2 Characteristics of the grid

Many nodes:	99
Many meshs and types:	40 HEXA8

6 Results of modeling B

6.1 Values tested

Identification	Reference	*Aster*	% difference	tolerance
Temperature at the point B in °C				
N91	653.85	653.87	0,003	2%
N92	653.85	653.87	0,003	2%
N97	653.85	653.87	0,003	2%
N98	653.85	653.87	0,003	2%

7 Summary of the results

This test is recommended by NAFEMS (but with another type of grid).
Two modelings give very satisfactory results, the maximum change obtained is of 0,003%.

For modeling PLAN, in spite of nonthe - symmetry of the grid, one notes that the temperature with the nodes (points of observation) pertaining to the TRIA3 and the QUAD4 is identical.

The limiting condition of radiation was imposed via a nonlinear loading of flow (flow function of the temperature). In this test the taking into account of the radiation is completely correct.

This test with licence to test order AFFE_CHAR_THER_F in the case of (associate with operand FLUX_NL which makes it possible to affect a flow non_linéaire) modelings PLAN and 3D.