TTLL301 - Heat transfer in a bar with imposed temperature (sinusoid)

Summarized:

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

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

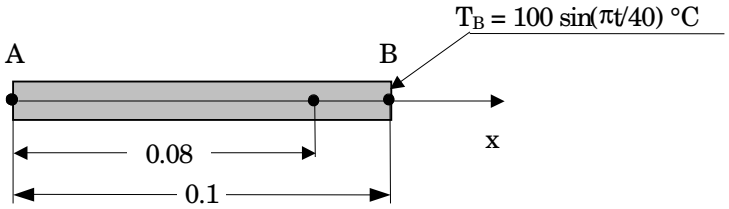
The features tested are the following ones:
1.plane thermal element,
2.voluminal thermal element,
3.algorithm of transient thermal,
4.conditions limiting: sinusoidal variation of the temperature imposed in the course of time.

The interest of the test lies in the taking into account of the variation in the temperature imposed in the course of time and the geometrical discretization.

The results are compared with those provided by NAFEMS.

1 Problem of reference

1.1 Geometry



Dimensions in meters

1.2 Properties of the thermal

$\lambda = 35\ W/m°C$ material conductivity
$C_p = 440.5\ J/kg°C$ specific heat
$\rho = 7200\ kg/m^3$ density

1.3 Boundary conditions and loadings

- temperature imposed on point: $A \quad T_A = 0°C$,
- temperature imposed on point: $B \quad T_B = 100 \sin(\pi t/40)°C$.

1.4 Initial conditions

$t = 0 \ : \ T(x) = 0°C$

2 Reference solution

2.1 Méthode de calcul used for the reference solution

the reference solution is that given in file “TEST n° T3” of the tests of reference published by NAFEMS.

2.2 Results of reference

Temperature to the point $x=0.08$ at time $t=32\,s$

2.3 Uncertainty on the solution

Nonavailable on file NAFEMS.

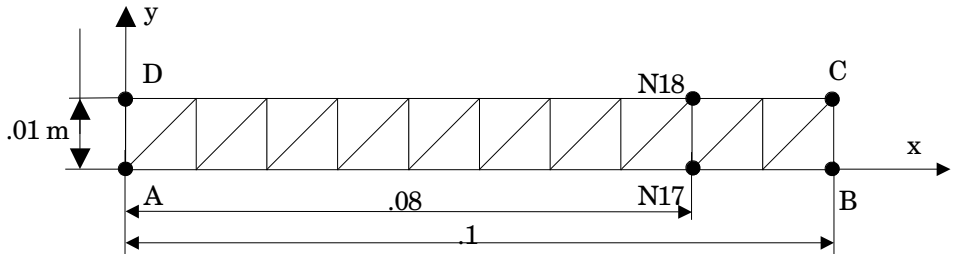
2.4 Bibliographical references

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

3 Modelization A

3.1 Characteristic of the modelization

PLANE (TRIA3)



Conditions limites:

- cotés AB CD $\varphi = 0$
- coté AD $T = 0\ °C$
- coté BC $T = 100 \sin(\pi t/40)\ °C$

3.2 Characteristic of the mesh

Many nodes:	22
Number of meshes and types:	10 TRIA3

3.3 Remarks

the discretization in time step are the following one:

5pas	poursoit	$[0.,1.0D+0]$	$\Delta t = 2.D-1$
18pas	poursoit	$[1.D+0,1.0D+1]$	$\Delta t = 5.D-1$
20pas	poursoit	$[1.D+1,2.0D+1]$	$\Delta t = 5.D-1$
20pas	poursoit	$[2.D+1,3.0D+1]$	$\Delta t = 5.D-1$
10pas	poursoit	$[3.D+1,3.5D+1]$	$\Delta t = 5.D-1$

4 Results of the modelization A

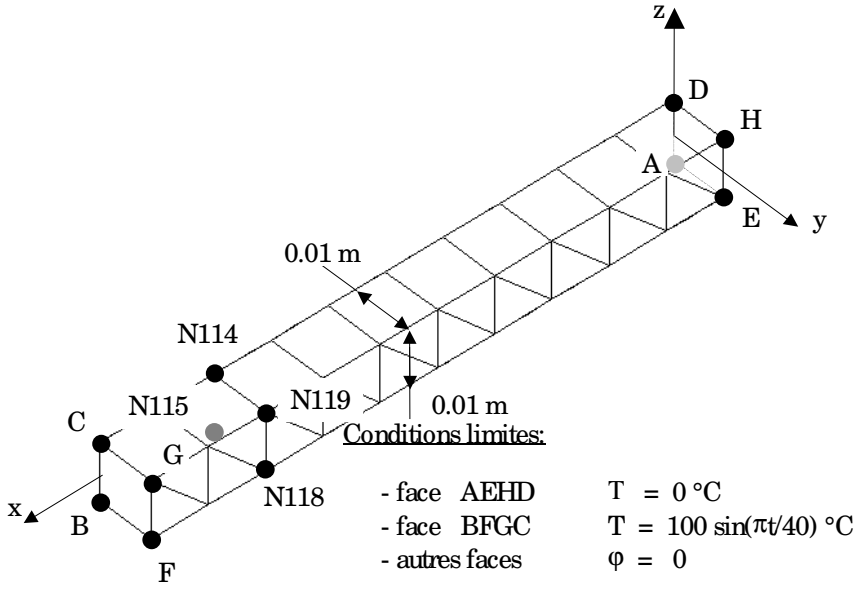
4.1 Values tested

Identification	Reference	% difference	Tolerance
Temperature to point: $x=0.08\,m$ to $t=32\,s$	$T(°C)$		
$N17$	36.60	3.480	2%
$N18$	36.60	1.036	2%

5 Modelization B

5.1 Characteristic of the modelization

Modelization: 3D (PENTA15)



5.2 Characteristic of the mesh

Many nodes:	148
Number of meshes and types:	20 PENTA15

5.3 Remarks

the discretization in time step are the following one:

5pas poursoit	$[0.,1.0D+0]$	$\Delta t=2.D-1$	
18pas	poursoit	$[1.D+0,1.0D+1]$	$\Delta t=5.D-1$
20pas	poursoit	$[1.D+1,2.0D+1]$	$\Delta t=5.D-1$
20pas	poursoit	$[2.D+1,3.0D+1]$	$\Delta t=5.D-1$
10pas	poursoit	$[3.D+1,3.5D+1]$	$\Delta t=5.D-1$

6 Results of the modelization B

6.1 Values tested

Identification	Reference	Tolerance
Temperature to point: $x=0.08\,m$ to $t=32\,s$		
N114	36.60	2%
N115	36.60	2%
N118	36.60	2%
N119	36.60	2%

7 Summary of the results

This test are recommended by NAFEMS (but with another type of mesh).
The two modelizations carried out give the following results:

- modelization A (PLANE with meshes TRIA3), the maximum change (3.48%) is higher than the tolerance fixed initially (2%),
- modelization B (3D with meshes PENTA15), the maximum change (0.36%) is lower than the tolerance fixed initially (2%).

The limiting condition is given by means of the command FORMULATES. This choice allows a good representation of the taking into account of sinusoidal the limiting formal requirement.

The modelization quadratic is adapted to simulate this test. A mesh finer and balanced for the linear modelization would make it possible to get better results.
The results of the modelization A are thus regarded as acceptable.

The principal interest of this test is its origin: NAFEMS.