TTLV300 - Parallelepiped subjected to one density flux on its sides

Summarized:

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

It is about a voluminal problem represented by a modelization 3D.

The features tested are the following ones:
- voluminal thermal element,
- algorithm of transient thermal,
- conditions limiting: imposed flux.

The results are compared with a three-dimensional analytical solution.

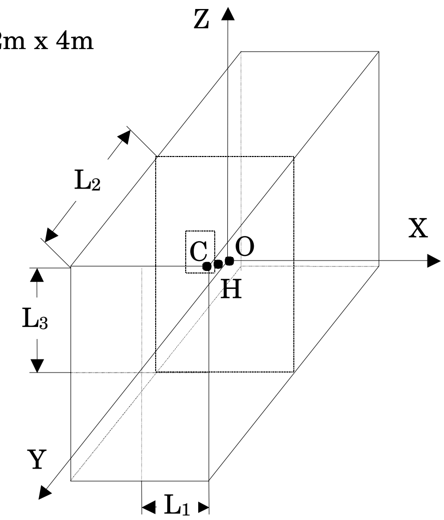
1 Problem of reference

1.1 Geometry

Dimensions du parallélépipède: 2m x 3.2m x 4m

- L_1 = 1.0 m
- L_2 = 1.6 m
- L_3 = 2.0 m

Point O (0.,0.,0.)
Point H (0.5,0.8,1.0)
Point C (1.0,1.6,2.0)



1.2 Properties of the thermal

$\lambda=1.\,W/m\,°C$	material conductivity
$c_p=1.\,J/kg\,°C$	specific heat
$\rho=1.\,kg/m^3$	density

1.3 Boundary conditions and loadings

Flux imposed on the 6 sides $q=0.5\,W/m^2=q_w$

1.4 Initial conditions

$T(t=0)=1\,°C=T_0$

2 Reference solution

2.1 Method of calculating used for the reference solution

$T(x, y, z, t)=T_0+2\mathrm{q}_w\frac{\sqrt{\alpha t}}{\lambda}(A+B+C)$ with:

$$A=\sum_{m=0}^{\infty}\left[i.erfc\left[\frac{(2\mathrm{m}-1)L_1+x}{2\sqrt{\alpha t}}\right]+i.erfc\left[\frac{(2\mathrm{m}-1)L_1-x}{2\sqrt{\alpha t}}\right]\right]$$

$$B=\sum_{m=0}^{\infty}\left[i.erfc\left[\frac{(2\mathrm{m}-1)L_2+y}{2\sqrt{\alpha t}}\right]+i.erfc\left[\frac{(2\mathrm{m}-1)L_2-y}{2\sqrt{\alpha t}}\right]\right]$$

$$C=\sum_{m=0}^{\infty}\left[i.erfc\left[\frac{(2\mathrm{m}-1)L_3+z}{2\sqrt{\alpha t}}\right]+i.erfc\left[\frac{(2\mathrm{m}-1)L_3-z}{2\sqrt{\alpha t}}\right]\right]$$

$$\alpha=\frac{\lambda}{\rho C_p}$$

The values of reference are obtained with $m=1000$.

2.2 Results of reference

Temperature to the points: $O(0{,}0{,}0)$, $H(0.5{,}0.8{,}1.)$ and $C(1.{,}1.6{,}2.)$

2.3 Uncertainty on the analytical

solution Solution.

2.4 Bibliographical references

• M.J Chang, L.C Chow, W.S Chang, “Improved alternating direction implicit for solving transient three dimensional heat diffusion problems”, Numerical Heat Transfer, flight 19, pp 69-84, 1991.

3 Modelization A

3.1 Characteristic of the modelization

3D (HEXA8, PENTA6)

Modélisation 1/8 du parallélépipède

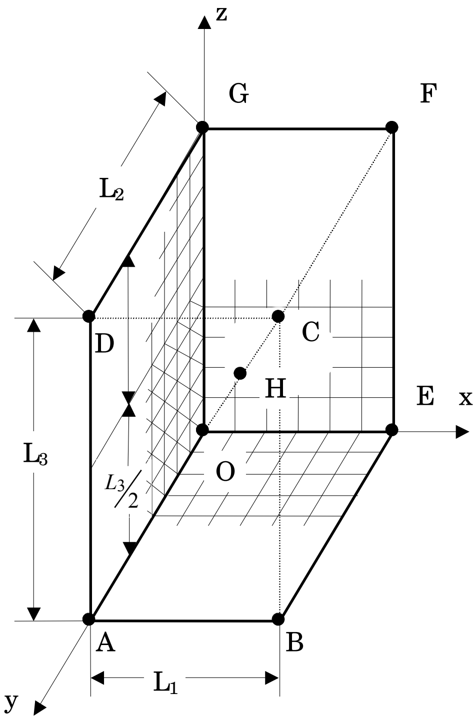
Maillage:

- 6 éléments suivant x
- 8 éléments suivant y
- 10 éléments suivant z

Conditions limites:

- faces [ABCD], [BEFC], [DCFG]: $q_w = 0.5$
- faces [ABEO], [AOGD], [OEFG]: $\varphi = 0.$

Points	x	y	z	Noeud
O	0.00	0.00	0.00	N2
H	0.50	0.8	1.00	N409
C	1.00	1.6	2.00	N814



3.2 Characteristic of the mesh

Many nodes: 819
Number of meshes and types: 288 HEXA8, 576 PENTA6 (168 QUAD4, 96 TRIA3)

3.3 Remarks

the limiting condition $\varphi=0.$ is implicit on free edges.
Discretization of time: 36 intervals, enters $0.s$ and $10s$ (of $0.005s$ with $1.s$ by interval).

4 Results of the modelization A

4.1 Values tested

Identification	**Reference**	***Aster***	**% difference**	**Tolerance**
Not O				
(N2) T = 0.05 S	1.0001	1.00000443	-0.010	1%
T = 0.1 S	1.00398	1.003172	-0.080	1%
T = 0.2 S	1.03331	1.03127	-0.198	1%
T = 0.3 S	1.08533	1.08227	-0.282	1%
T = 0.5 S	1.23086	1.2266	-0.345	1%
T = 1. S	1.69979	1.6945	-0.311	1%
T = 5. S	5.9292	5.9234	-0.098	1%
T = 10. S	11.242	11.236	-0.054	1%
Point H				
(N409) T = 0.05 S	1.0083	1.006472	- 0.181	1%
T = 0.1 S	1.03819	1.03573	- 0.237	1%
T = 0.2 S	1.12556	1.1229	- 0.235	1%
T = 0.3 S	1.22594	1.2233	-0.217	1%
T = 0.5 S	1.43580	1.4331	-0.188	1%
T = 1. S	1.96667	1.9639	-0.140	1%
T = 5. S	6.2167	6.2139	-0.045	1%
T = 10. S	11.529	11.526	-0.023	1%
Point C				
(N814) T = 0.05 S	1.3785	1.3726	-0.429	1%
T = 0.1 S	1.5352	1.5308	-0.290	1%
T = 0.2 S	1.7572	1.7536	-0.206	1%
T = 0.3 S	1.9295	1.9261	-0.176	1%
T = 0.5 S	2.2142	2.2110	-0.146	1%
T = 1. S	2.8085	2.8054	-0.112	1%
T = 5. S	7.0792	7.0762	-0.043	1%
T = 10. S	12.392	12.389	-0.027	1%

5 Summary of the results

got results are satisfactory. The maximum change (0.43%), is located on surface external of the parallelepiped (Not C) at the t weakest time. At the end of $10\,s$, this variation decreases, the maximum is then of 0.054% (point: O center parallelepiped).

This test made it possible 3D to test in linear transient `the modelization` with meshes `HEXA8` and `PENTA6`.