# TTLV300 - Parallelepiped subjected to a density flux on its faces

**Summary:**

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

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

The features tested are the following ones:

- voluminal thermal element,
- transitory algorithm of thermics,
- limiting conditions: imposed flow.

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

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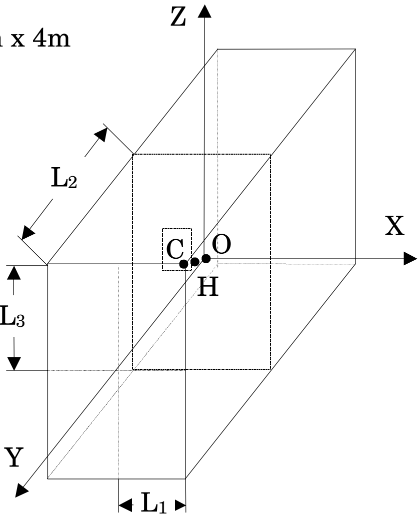
# 1 Problem of reference

## 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 material

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

## 1.3 Boundary conditions and loadings

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

## 1.4 Initial conditions

$T(t=0) = 1\,°C = T_0$

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# 2 Reference solution

## 2.1 Method of calculating used for the reference solution

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

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

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

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

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

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

## 2.2 Results of reference

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

## 2.3 Uncertainty on the solution

Analytical 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.


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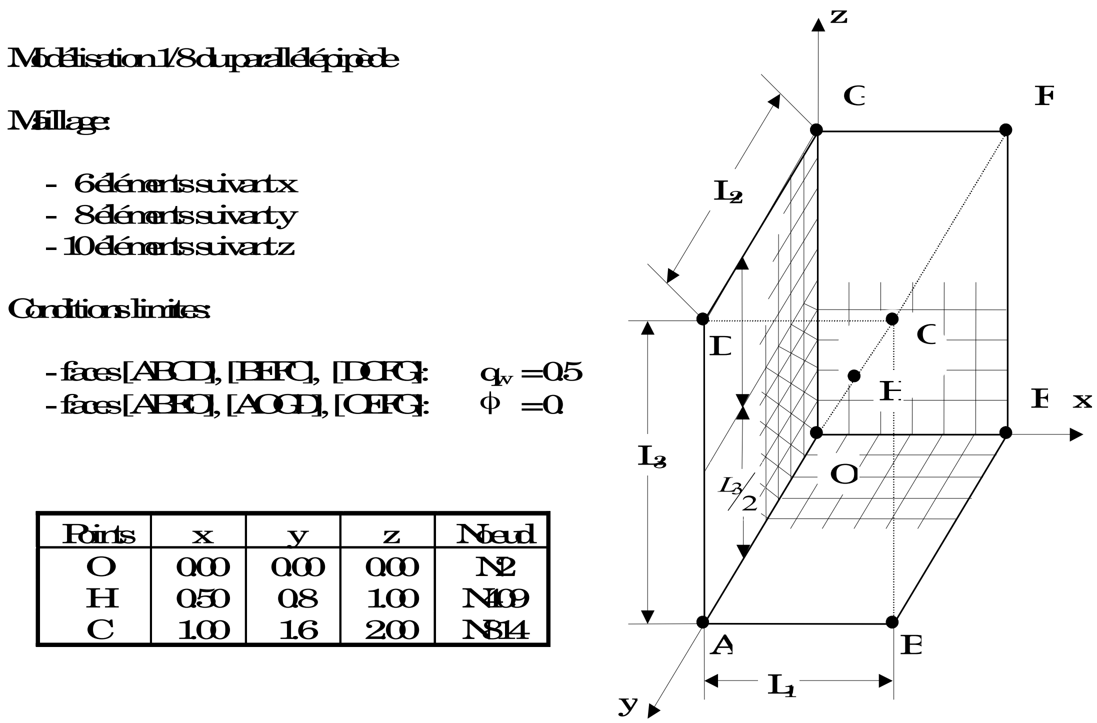
# 3 Modeling A

## 3.1 Characteristics of modeling

3D (HEXA8, PENTA6)




| 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 Characteristics of the grid

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

## 3.3 Remarks

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

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# 4 Results of modeling 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% |
| | | | | |
| Not 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% |
| | | | | |
| Not 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% |

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# 5 Summary of the results

The got results are satisfactory. The maximum change (0.43%), is located on surface external of the parallelepiped (Not $C$) at the moment $t$ weakest. At the end of $10\,s$, this variation decreases, the maximum is then of 0,054% (not $O$ : center of the parallelepiped).

This test made it possible to test in linear transient modeling 3D with meshs HEXA8 and PENTA6.

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