

TPLA05 - Bar cylindrical with density flux

Summary:

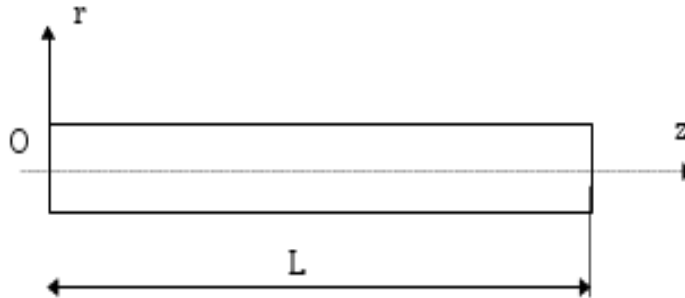
This test is resulting from the validation independent of version 3 in linear stationary thermics.

It understands two modelings, the first which tests the voluminal elements, the second, the axisymmetric elements 2D.

Boundary conditions in imposed temperature and of density flux are taken into account.
The results resulting from this case test are compared with those provided by VPCS.

1 Problem of reference

1.1 Geometry



$r=0.01\text{ m}$ (ray of the cylinder)
 $L=1\text{ m}$

1.2 Properties of material

$\lambda=33.33\text{ W/m}^\circ\text{C}$ Thermal conductivity

1.3 Boundary conditions and loadings

- Imposed temperatures,

$$\begin{aligned} T &= 0^\circ\text{C} && \text{in } z=0. \\ T &= 500^\circ\text{C} && \text{in } z=1. \end{aligned}$$

- Constant density flux on cylindrical surface: $\varphi = -200\text{ W/m}^2$ (outgoing flow).

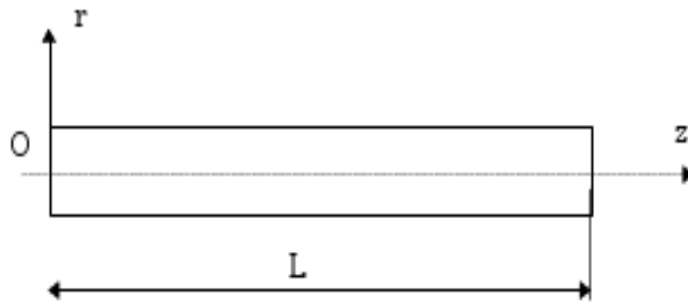
1.4 Initial conditions

Without object.

2 Reference solution

2.1 Method of calculating used for the reference solution

The reference solution is that given in card TPLA05/89 of guide VPCS



- Temperature according to z : $T(z) = \frac{-\Phi}{\lambda r} z(z-L) + T_1 \cdot \frac{z}{L}$
- $T(z=0) = 0$ $T(z=L) = T_1$.

The cylinder is supposed infinitely long ($L \gg r$)

The temperature minimum is of $-4.17^\circ C$ in $z = 0.083 m$

2.2 Results of reference

Temperature in $z = 0, 0.1, \dots, 0.8, 0.9, 1.0$

2.3 Uncertainty on the solution

< 1 %

Approximate analytical solution (approximation: $T = cte$, for all r)

2.4 Bibliographical references

- [1] Guide of validation of the software packages of structural analysis. French company of the Mechanics, AFNOR 1990 ISBN 2-12-486611-7

3 Modeling A

3.1 Characteristics of modeling

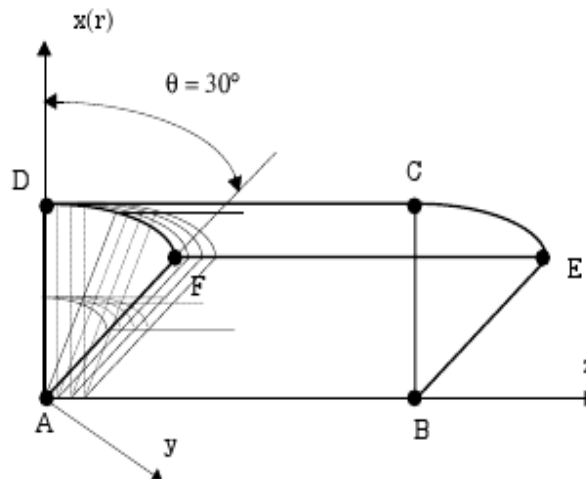
3D (PENTA15, HEXA20)

Conditions limites:

- faces ABCD, ABEF $\varphi = 0$
- face DFEC $\varphi = -200 \text{ w/m}^2$
- face AFD $T = 0^\circ\text{C}$
- face BEC $T = 500^\circ\text{C}$

Découpage:

- 80 éléments suivant z
- 2 éléments suivant θ
- 2 éléments suivant x



3.2 Characteristics of the grid

Many nodes: 1937
Many meshes and types: 160 PENTA15, 160 HEXA20 (and 160 QUAD8)

3.3 Sizes tested and results

Identification	Reference	tolerance
Temperature ($^\circ\text{C}$)		
Z = 0.0 R = .0 (n1 : A)	0.00	.00001
R = .01 (n17 : D)	0.00	.00001
Z = 0.1 R = .0 (n193)	4.00	1%
R = .01 (n209)	4.00	1%
Z = 0.2 R = .0 (n385)	4.00	1%
R = .01 (n401)	4.00	1%
Z = 0.3 R = .0 (n577)	24.00	1%
R = .01 (n593)	24.00	1%
Z = 0.4 R = .0 (n769)	56.00	1%
R = .01 (n785)	56.00	1%
Z = 0.5 R = .0 (n961)	100.00	1%
R = .01 (n977)	100.00	1%
Z = 0.6 R = .0 (n1153)	156.00	1%
R = .01 (n1169)	156.00	1%
Z = 0.7 R = .0 (n1345)	224.00	1%
R = .01 (n1361)	224.00	1%
Z = 0.8 R = .0 (n1537)	304.00	1%
R = .01 (n1553)	304.00	1%
Z = 0.9 R = .0 (n1729)	396.00	1%
R = .01 (n1745)	396.00	1%
Z = 1.0 R = .0 (n1921: B)	500.00	.00001

R = .01 (n1937: C) 500.00 .00001

(*: Imposed temperature)

3.4 Remarks

Voluminal heat ρC_p does not intervene in this test, but must be declared for *Code_Aster*. One takes $\rho C_p = 1.0 \text{ J/m}^3 \text{ }^\circ\text{C}$.

The limiting condition $\varphi = 0$. is implicit on the free edges.

4 Modeling B

4.1 Characteristics of modeling

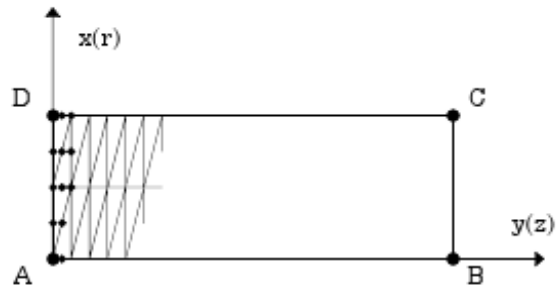
AXIS (TRIA6)

Conditions limites:

- coté CD $\phi = -200 \text{ W/m}^2$
- coté AD $T = 0^\circ\text{C}$
- coté BC $T = 500^\circ\text{C}$

Découpage:

- 80 éléments suivant y
- 2 éléments suivant x



4.2 Characteristics of the grid

Many nodes: 805
Many meshes and types: 320 TRIA6 (and 80 SEG3)

4.3 Sizes tested and results

Identification	Reference	tolerance
Temperature ($^\circ\text{C}$)		
Z = 0.0 R = .0 (n1 : A)	0.00	00001
R = .01 (n5 : D)	0.00	00001
Z = 0.1 R = .0 (n81)	4.00	1%
R = .01 (n85)	4.00	1%
Z = 0.2 R = .0 (n161)	4.00	1%
R = .01 (n165)	4.00	1%
Z = 0.3 R = .0 (n241)	24.00	1%
R = .01 (n245)	24.00	1%
Z = 0.4 R = .0 (n321)	56.00	1%
R = .01 (n325)	56.00	1%
Z = 0.5 R = .0 (n401)	100.00	1%
R = .01 (n405)	100.00	1%
Z = 0.6 R = .0 (n481)	156.00	1%
R = .01 (n485)	156.00	1%
Z = 0.7 R = .0 (n561)	224.00	1%
R = .01 (n565)	224.00	1%
Z = 0.8 R = .0 (n641)	304.00	1%
R = .01 (n645)	304.00	1%
Z = 0.9 R = .0 (n721)	396.00	1%
R = .01 (n725)	396.00	1%
Z = 1.0 R = .0 (n801: B)	500.00	00001
R = .01 (n805: C)	500.00	00001

(*: Imposed temperature)

4.4 Remarks

Voluminal heat ρC_p does not intervene in this test, but must be declared for *Code_Aster*. One takes $\rho C_p = 1.0 \text{ J/m}^3 \text{ }^\circ\text{C}$.

The limiting condition $\varphi = 0$. is implicit on the free edges.

5 Summary of the results

The got results are satisfactory, the maximum change is of 0.63%. Modeling 3D (with meshes PENTA15, HEXA20) and modeling AXIS (with meshes TRIA6) give the same results appreciably (the grid and the degree of interpolation are identical).

The analytical solution which is an approached solution, supposes that the report r/L is much higher than 1. For this digital test, the report r/L was taken equal to 100.