TPLA05 - Cylindrical bar with density flux

Summarized:

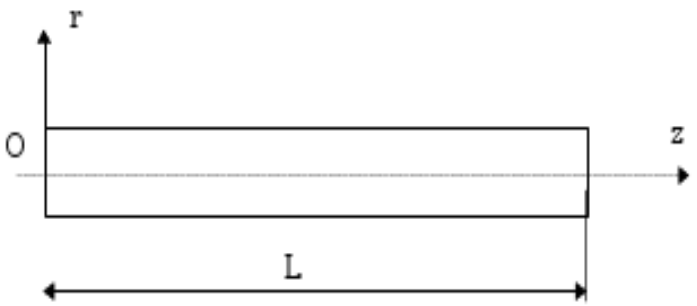
This test is resulting from the validation independent of version 3 in linear steady thermal.

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

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



$r = 0.01\,m$ (radius of the cylinder)
$L = 1\mathrm{m}$

1.2 Properties of the thermal

$\lambda = 33.33\,W/m\,°C$ material Conductivity

1.3 Boundary conditions and loadings

- Temperatures imposed,

  $T = 0\,°C$ in $z = 0.$
  $T = 500\,°C$ of $z = 1.$

- constant Density flux on cylindrical surface: $\varphi = -200\,W/m^2$ (outgoing flux).

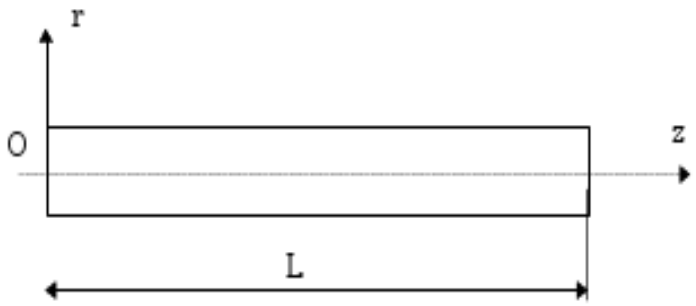
1.4 Initial conditions

Without object.

2 Reference solution

2.1 Method of calculating used for the reference solution

the reference solution is that given in file TPLA05/89 of guide VPCS



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

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

the temperature minimum is of $-4.17\,°C$ in $z=0.083\,m$

2.2 Results of reference

Temperature in $z=0.,0.1,...,0.8,0.9,1.0$

2.3 Uncertainty on the solution

$<1\%$
approximate analytical Solution (approximation: $T=cte$, for all r)

2.4 bibliographical References

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

3 Modelization A

3.1 Characteristic of the modelization

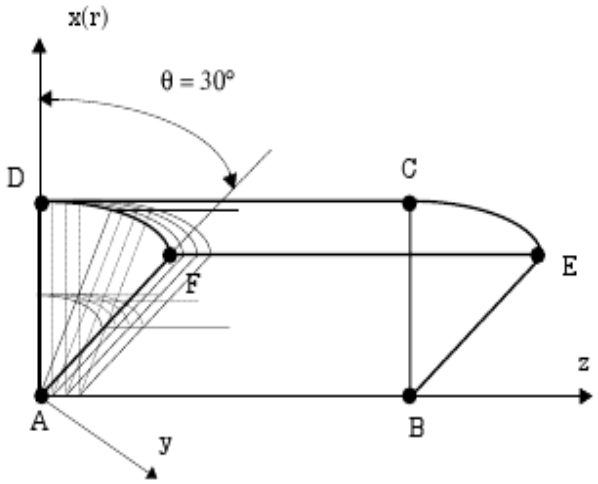
3D (PENTA15, HEXA20)

Conditions limites:

- faces ABCD, ABEF φ = 0
- face DFEC φ = -200 w/m²
- face AFD T= 0°C
- face BEC T= 500°C

Découpage:

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



3.2 Characteristic of the mesh

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

3.3 Quantities tested and results

Identification	Reference	tolerance
Temperature (°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 $\rho C_P = 1.0 J/m^3 °C$.

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

4 Modelization B

4.1 Characteristic of modelization

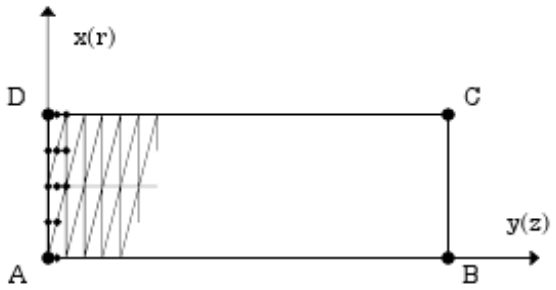
AXIS (TRIA6)

Conditions limites:

- coté CD φ = -200.W/m²
- coté AD T = 0°C
- coté BC T = 500°C

Découpage:

- 80 éléments suivant y
- 2 éléments suivant x



4.2 Characteristic of the mesh

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

4.3 Quantities tested and results

Identification	Reference	tolerance
Temperature (°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 *the Code_Aster*. One takes $\rho C_P = 1.0 J/m^3 °C$.

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

5 Summary of the results

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

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