TPLA04 - Release of power in a hollow roll

Summary:

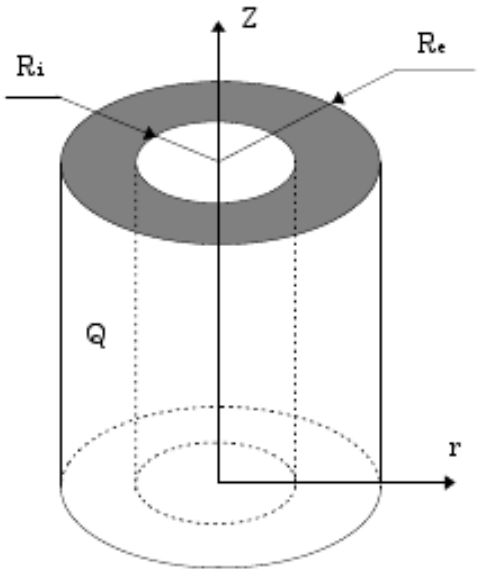
This test is resulting from the validation independent of version 3 in linear stationary thermics.

It comprises an axisymmetric modeling 2D which tests the axisymmetric elements in thermics, the boundary conditions in imposed temperature and the boundary conditions of type source of heat.

This test aims to validate the taking into account of the source of heat by comparing the results got with those provided by VPCS.

1 Problem of reference

1.1 Geometry



Interior ray	$R_i = 1\text{m}$
External ray	$R_e = 2\text{m}$
Length	l

1.2 Properties of material

$\lambda = 1.0\, W/m\,°C$ Thermal conductivity

1.3 Boundary conditions and loadings

- Imposed temperatures:
- Interior surface: $T_i = T(r = R_i) = 20\,°$
  External surface: $T_e = T(r = R_e) = 20\,°$
- Uniform released power $Q = 100\text{W}/m^3$

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 TPLA04/89 of guide VPCS.

- Temperature according to r :

$$T(r)=T_i+\frac{Q}{4\lambda}\left[(R_e^2-R_i^2)\frac{\ln(\frac{r}{R_i})}{\ln(\frac{R_e}{R_i})}-(r^2-R_i^2)\right]$$

- Density flux according to r :

$$\Phi(r)=-\lambda\frac{dT}{dr}=-\frac{Q}{4r}\left[\frac{(R_e^2-R_i^2)}{\ln(\frac{R_e}{R_i})}-2\mathrm{r}^2\right]$$

The cylinder is supposed infinitely long ($l \gg R_e$)

2.2 Results of reference

Temperature and density flux for $r=1.0\,,\,1.2\,\mathrm{et}\,1.5$

2.3 Uncertainty on the solution

Analytical solution.

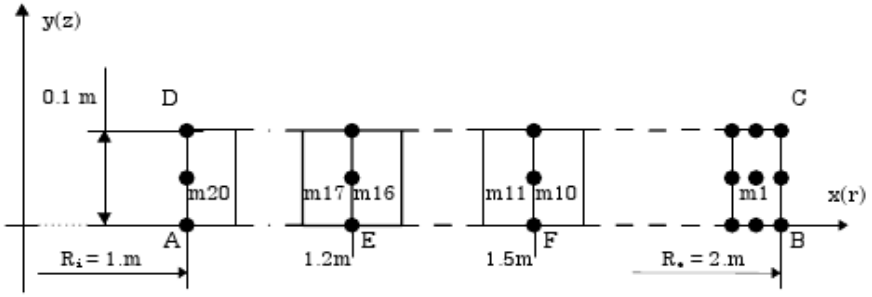
2.4 Bibliographical references

[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

AXIS (QUAD9)



Conditions limites:

- cotés AD, BC T = 20 °C
- tout Q = 100 W/m³
- cotés AB, CD φ = 0. W/m²

Point	r	z	Noeud
A	1.0	0.0	N1
D	1.0	0.1	N3
E	1.2	0.0	N25
F	1.5	0.0	N61
B	2.0	0.0	N121
C	2.0	0.1	N123

3.2 Characteristics of the grid

Many nodes: 123
Many meshs and types: 20 QUAD9

3.3 Remarks

Voluminal heat ρC_P does not intervene in this test, but must obligatorily be declared. One takes $\rho C_P = 2.0\, J/m^3 °C$

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

3.4 Sizes tested and results

Identification	Reference	*Code_Aster*	% difference	tolerance
Temperature (°C)				
Node n1 (A: R = 1.0)	20.00	20.0000	0.000%*	1%
Node n25 (E: R = 1.2)	28.73	28.7276	0,008%	1%
Node n61 (F: R = 1.5)	32.62	32.6222	0,007%	1%
Density flux (W/m^2)				
Mesh m20 n1 (R = 1.0)	-58.20	-58.1592	-0,070%	1%
Mesh m17 n25 (R = 1.2)	-30.17	-30.1412	-0,095%	1%
Mesh m16 n25 (R = 1.2)	-30.17	-30.1434	-0,088%	1%
Mesh m11 n61 (R = 1.5)	2.87	2.8791	0,316%	1%
Mesh m10 n61 (R = 1.5)	2.87	2.8782	0,285%	1%

4 Summary of the results

The got results are very satisfactory. The maximum change is of -0,008% in temperature and 0,316% in flow.

This test made it possible to test the taking into account of a source term within meshs QUAD9 with a modeling AXIS (AFFE_CHAR_THER associated with the keyword SOURCE).