TPLA01 - Infinite hollow roll in balance thermics

Summary:

Linear stationary thermics.

Axisymmetric model; 4 modelings.

Analytical solution.

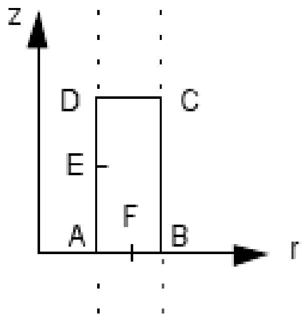
Interest of the test:

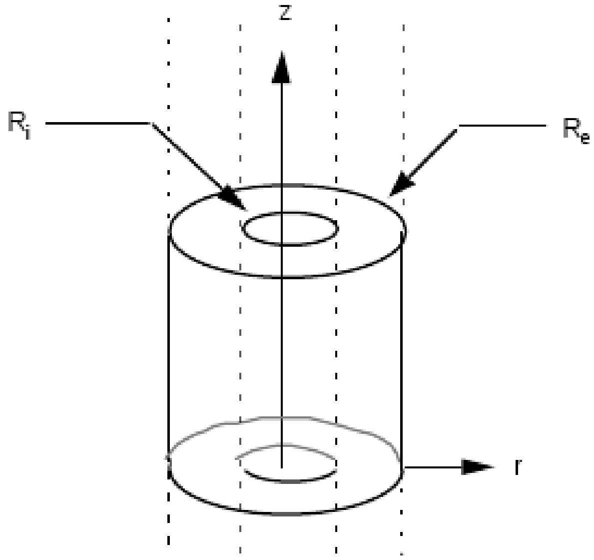
- **all** axisymmetric elements: triangles and quadrangles, linear and quadratic,
- axisymmetric element of hull: quadratic segments
- boundary conditions varied: exchange, imposed temperature, imposed flow,
- validation partial of the matrix of thermal “mass” because one makes “a false” transient.
- Option `'MASS_THER'` of `CALC_MATR_ELEM` for modeling A

The results are not affected by the distortion of the meshs $h/l=40$.

1 Problem of reference

1.1 Geometry





Interior ray	$R_i = 0.30\,m$
External ray	$R_e = 0.35\,m$
Not F	$r = 0.32\,m$

1.2 Material properties

$\lambda = 1\,W/m\,°C$

$\rho\,C_P = 2\mathrm{J}/m^3\,°C$ (voluminal heat)

1.3 Boundary conditions and loadings

- $[DC] \cup [AB]$: $\Phi = 0\,W/m^2$
- $[EA]$: $T = T_i = 100\,°C$
- $[ED]$: $\Phi = \Phi_i = 1729.9091\,W/m^2$ (returning flow)
- $[CD]$: : exchange $h = h_e = 500\,W/m^2\,°C$
  $T = T_e = 17.03444\,°C$

1.4 Initial conditions

To do this stationary calculation, a transitory calculation is done for which the boundary conditions are constant in time. This makes it possible to test elementary calculations of mass intervening in the first member as well as the second member.

2 Reference solution

2.1 Method of calculating used for the reference solution

$$T(r) = T_i + \Phi \log\left(\frac{r}{R_i}\right)$$

with:

$$\begin{cases} \Phi = \dfrac{T_e - Ti}{\log\left(\dfrac{R_e}{R_i}\right)} \\ \text{les flux } radiaux \left(\lambda \dfrac{\partial T}{\partial r}\right) \text{sur les parois du cylindre sont :} \\ \Phi_i = +\lambda . \dfrac{\Phi}{R_i} \\ \Phi_e = +\lambda . \dfrac{\Phi}{R_e} \end{cases}$$

T_i: Temperature in skin “interns”
T_e: Temperature in “external” skin

2.2 Results of reference

Temperatures and flow at the points A, B, D, F.

For the test of the option 'MASS_THER' (operator CALC_MATR_ELEM), one must use a value given by an object JEVEUX, which corresponds to a sum of control.
It is a test of pure digital not-regression.
To test, one activates the debug mode calculation. F90 then one compares the values of the fields of exit of MASS_THER in CALC_MATR_ELEM with the same thing as it THER_LINEAIRE test.

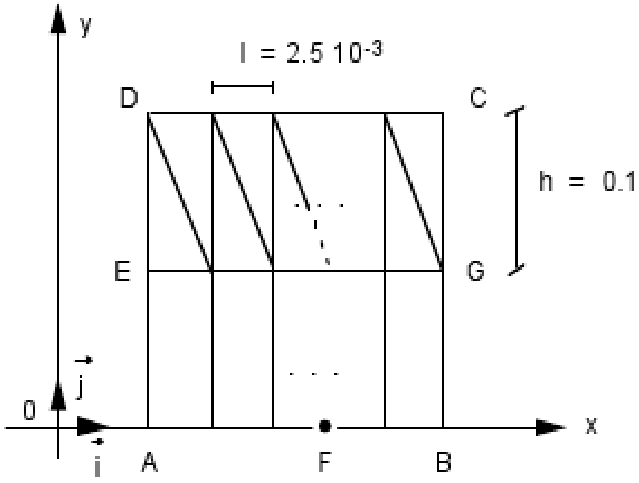
2.3 Uncertainty on the solution

Analytical solution.

3 Modeling A

3.1 Characteristics of modeling

axis (TRIA3, QUAD4)



	x	y	
A	0.30	0.00	$N1$
B	0.35	0.00	$N41$
D	0.30	0.10	$N43$
E	0.30	0.05	$N2$
F	0.32	0.00	$N17$

3.2 Characteristics of the grid

Many nodes: 63.

Many meshs and types: 40 TRIA3, 20 QUAD4

3.3 Values tested

Identification	Reference
$T(A)$	100
$T(B)$	20
$T(F)$	66,506
$T(D)$	100
$\Phi(A)$	1729.91
$\Phi(B)$	1482.78
$\Phi(D)$	1729.91
$\Phi(F)$	1621.79

4 Modeling B

4.1 Characteristics of modeling

axis (TRIA6, QUAD8)

	x	y	
A	0.30	0.00	$N180$
B	0.35	0.00	$N10$
D	0.30	0.10	$N178$
E	0.30	0.05	$N183$
F	0.32	0.00	$N112$

4.2 Characteristics of the grid

Many nodes: 185.

Many meshs and types: 40 TRIA6, 20 QUAD8

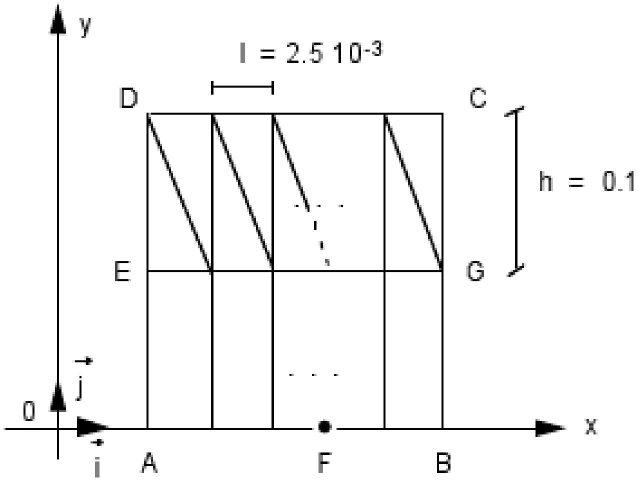
4.3 Values tested

Identification	Reference
$T(A)$	100
$T(B)$	20
$T(F)$	66,506
$T(D)$	100
$\Phi(A)$	1729.91
$\Phi(B)$	1482.78
$\Phi(D)$	1729.91
$\Phi(F)$	1621.79

5 Modeling C

5.1 Characteristics of modeling

axis (TRIA6, QUAD9)



	x	y	
A	0.30	0.00	$N199$
B	0.35	0.00	$N10$
D	0.30	0.10	$N197$
E	0.30	0.05	$N203$
F	0.32	0.00	$N124$

5.2 Characteristics of the grid

Many nodes: 205.

Many meshs and types: 40 TRIA6, 20 QUAD9

5.3 Values tested

Identification	Reference
$T(A)$	100
$T(B)$	20
$T(F)$	66,506
$T(D)$	100
$\Phi(A)$	1729.91
$\Phi(B)$	1482.78
$\Phi(D)$	1729.91
$\Phi(F)$	1621.79

6 Modeling D

6.1 Characteristics of modeling

COQUE_AXIS (SEG3)

6.2 Characteristics of the grid

Many nodes: 21.

Many meshs and types: 10 SEG3

6.3 Values tested

Identification	Size	Type of Reference	Reference	Tolerance (%)
$r=0.3(A)$	TEMP_SUP TEMP_MIL TEMP_INF	'ANALYTICAL'	100	0.1
$r=0.31$		'ANALYTICAL'	82.983	0.1
$r=0.32$		'ANALYTICAL'	66.5063	0.1
$r=0.33$		'ANALYTICAL'	50.5366	0.1
$r=0.34$		'ANALYTICAL'	35.0437	0.1
$r=0.35(B)$		'ANALYTICAL'	20	0.1

7 Summary of the results

This problem is correctly solved:

- with the various types of elements whatever the degree of interpolation,
- is not affected by the shape of the elements $h/l=40$.