TPLV305 - Heat gradient in a cylinder (Fourier)

Summarized:

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

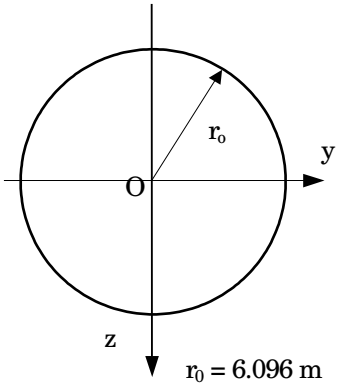
It validates the axisymmetric thermal elements of harmonic resolution (AXIS_FOURIER) and voluminal with for boundary conditions of the temperatures imposed according to a harmonic function (mode 1).

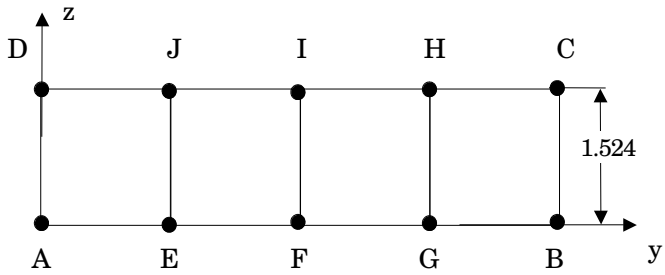
It comprises two modelizations, one 3D and the other using of the axisymmetric thermal elements “Fourier”.

The interest of this test is the validation of thermal elements AXIS_FOURIER and of the command of assembly of the fields (CREA_CHAMP, option ASSE).

1 Problem of reference

1.1 Geometry





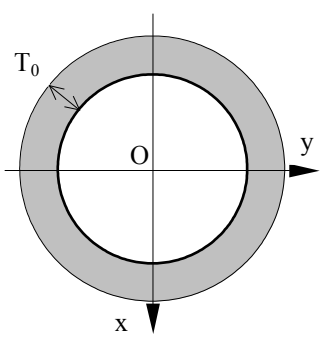
1.2 Properties of the thermal

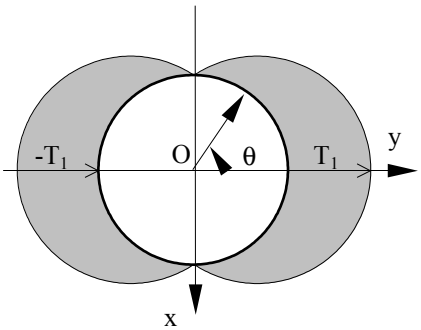
$\lambda = 1.7307\, W/m.\,°C$ material Conductivity

1.3 Boundary conditions and loadings

the limiting condition is applied to the external surface of the cylinder, it breaks up into:

- a symmetric limiting condition of revolution associated with harmonic 0:
  $CL1 \ : \ T_0 = -17.778\,°C$
- a symmetric limiting condition compared to θ associated with harmonic 1:
  $CL2 \ : \ T_1 \cos\theta = 44.444 \cos\theta\,(°C)$





1.4 Initial conditions

Without object.

2 Reference solution

2.1 Method of calculating used for the reference solution

the original reference solution given in the book [bib1] is based on an analytical approach. This reference is quoted in the handbook of checking of ANSYS [bib2]

2.2 Results of reference

- Temperature to the points A E F G, B for the mode 0 ($CL1$),
- Temperature at the points A E F G, B mode 0 and mode 1 recombined ($CL1+CL2$) for $\theta=0°, 45°, 90°$ and $180°$.

2.3 Uncertainty on the Unknown

solution, it was not possible to get the original reference (delivers old, more published).

2.4 References

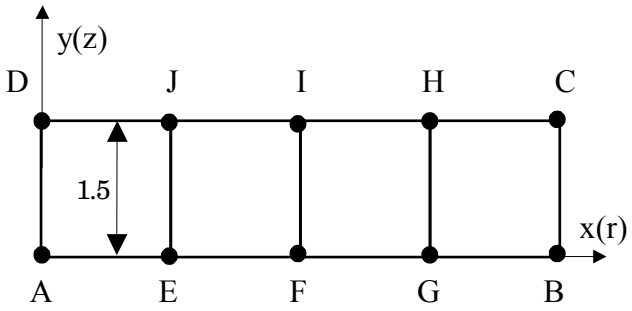
[1] Kreith, F., “Principles of heat transfer”, International Textbook Co., Scranton, Pennsylvania, 2nd Printing, 1959.

[2] ANSYS: “Checking manual”, 1 St edition, June 1,1976

3 Modelization A

3.1 Characteristic of modelization

AXIS_FOURIER (QUAD4)



Conditions limites:

- cotés AB, CD $\varphi = 0$
- coté BC
  . mode 0 T = -17.778
  . mode (0 +1) T = -17.778 +44.444 cos θ

Points	x	noeuds
A	0.000	N1 , N2
E	1.524	N3 , N4
F	3.048	N5 , N6
G	4.572	N7 , N8
B	6.096	N9 , N10

3.2 Characteristic of the mesh

Many nodes: 10
Number of meshes and types: 4 QUAD4

3.3 Quantities tested and relative

Identification		Reference	*Aster*	Variation results % difference	Variation results % tolerance	Absolute Deviation difference	Absolute Deviation tolerance
Temperature $(°C)$							
CL1 (mode = 0)							
	N1, N2	-17.778	-17.778	0.000	1%	-1.14e-12	0.01
	N3, N4	-17.778	-17.778	0.000	1%	-9.09e-13	0.01
	N5, N6	-17.778	-17.778	0.000	1%	-6.82e-13	0.01
	N7, N8	-17.778	-17.778	0.000	1%	-3.41e-13	0.01
	N9, N10 *	-17.778	-17.778	0.000	1%	0.000e+0	0.01
$CL1+CL2$ (mode 0 and 1)							
$\theta=0$	N1, N2	-17.778	-17.778	0.000	1%	-1.14e-12	0.01
	N3, N4	-6.667	-6.667	0.000	1%	1.820e-8	0.01
	N5, N6	4.444	4.444	0.000	1%	3.650e-8	0.01
	N7, N8	15.556	15.555	0.006	1%	-1.000e-3	0.01
	N9, N10 *	26.667	26.666	0.004	1%	-1.000e-3	0.01
$\theta=45$	N1, N2	-17.778	17.778	0.000	1%	-1.14e-12	0.01
	N3, N4	-9.921	-9.921	0.003	1%	-3.370e-4	0.01
	N5, N6	-2.064	-2.065	0.033	1%	-6.730e-4	0.01
	N7, N8	5.792	5.792	0.000	1%	-1.040e-5	0.01
	N9, N10	13.649	13.649	0.003	1%	-3.460e-4	0.01
$\theta=90$	N1, N2	-17.778	-17.778	0.000	1%	-1.14e-12	0.01
	N3, N4	-17.778	-17.778	0.000	1%	-9.09e-13	0.01

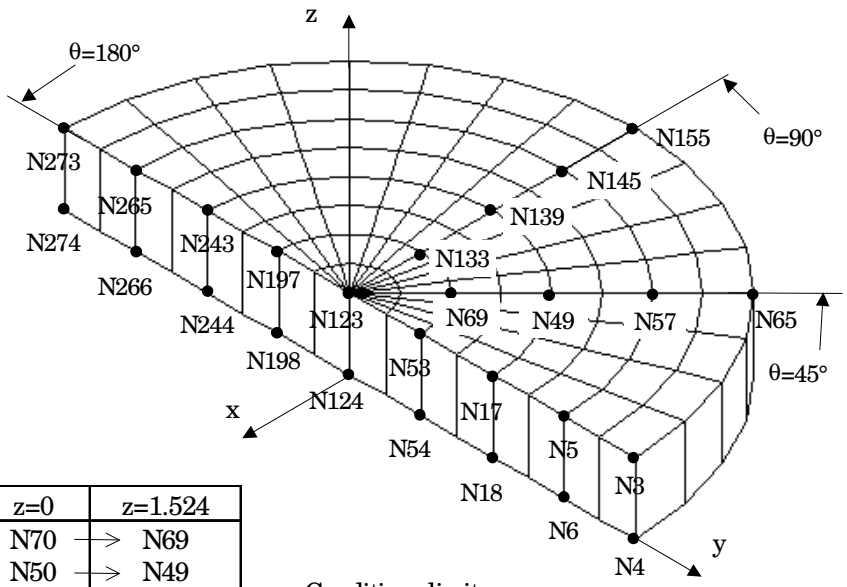
	N5, N6	-17.778	-17.778	0.000	1%	-5.68e-13	0.01
	N7, N8	-17.778	-17.778	0.000	1%	-2.27e-13	0.01
	N9, N10	-17.778	-17.778	0.000	1%	2.27e-13	0.01
$\theta=180$	N1, N2	-17.778	-17.778	0.000	1%	-1.14e-12	0.01
	N3, N4	-28.889	-28.889	0.000	1%	-1.820e-8	0.01
	N5, N6	-40.000	-40.000	0.000	1%	-3.650e-8	0.01
	N7, N8	-51.111	-51.111	0.000	1%	1.040e-6	0.01
	N9, N10	-62.222	-62.222	0.000	1%	2.27e-13	0.01

* imposed temperatures

4 Modelization B

4.1 Characteristic of the modelization

3D (PENTA6, HEXA8)



θ	z=0	z=1.524
45°	N70	N69
	N50	N49
	N58	N57
	N66	N65
90°	N134	N133
	N140	N139
	N146	N145
	N155	N154

Conditions limites:

- face externe (N8,N155,N273)
  T = -17.778 + 44.444 cos θ
- face interne (N8, N123, N273)
  φ = 0

4.2 Characteristic of the mesh

Many nodes:	274
Number of meshes and types:	128 (16 PENTA6, 112 HEXA8)

4.3 Remarks

computations were carried out by considering the complete loading $CL1+CL2$:

$$T_{imp}=-17.778+44.444\cos\theta$$

4.4 Quantities tested and relative

Identification		Reference	*Aster*	Variation results % difference	tolerance	Absolute Deviation difference	tolerance
$CL1+CL2$							
Temperature $(°C)$							
$\theta=0$	N123, N124	-17.778	-17.778	0.000	1%	-3.330e-5	0.01
	N53, N54	- 6.667	- 6.667	0.000	1%	1.330e-7	0.01
	N17, N18	4.444	4.444	0.001	1%	2.840e-5	0.01
	N5, N6	15.556	15.555	-0.006	1%	-9.730e-4	0.01
	N3, N4 *	26.667	26.666	-0.004	1%	-1.000e-3	0.01
$\theta=45$	N69, N70	-9.921	-9.921	0.003	1%	-3.460e-4	0.01
	N49, N50	-2.064	-2.065	0.031	1%	-6.480e-4	0.01
	N57, N58	5.792	5.792	0.001	1%	8.240e-5	0.01
	N65, N66 *	13.649	13.649	0.000	1%	-5.68e-13	0.01
$\theta=90$	N133, N134	-17.778	-17.778	0.000	1%	-3.750e-5	0.01
	N139, N140	-17.778	-17.778	0.000	1%	-5.030e-5	0.01
	N145, N146	-17.778	-17.778	0.000	1%	-6.990e-5	0.01
	N155, N156 *	-17.778	-17.778	0.000	1%	9.09e-13	0.01
$\theta=180$	N197, N198	-2.889	-2.889	0.000	1%	-6.440e-5	0.01
	N243, N244	-40.000	-40.000	0.000	1%	-7.680e-5	0.01
	N265, N266	-5.1111	-5.1111	0.000	1%	-5.210e-5	0.01
	N273, N274 *	-62.222	-62.222	0.000	1%	+6.82e-13	0.01

* temperatures imposed

5 Summary of the results

the two modelizations carried out (AXIS_FOURIER and 3D) give excellent results, the maximum change is of -0.006% for the two modelizations

This test made it possible to test in AXIS_FOURIER command CREA_CHAMP with the following operands:

- COMB_FOURIER to compute: the temperature in an angle given,
- ASSE to carry out a linear combination of modes 0 and 1.