
TTLA203 - Cylinder at temperatures imposed with adiabatic crack

Summary

This test aims to validate thermal elements axisymmetric X-FEM in transitory linear thermics.

One considers a full cylinder, fissured on the level of the section located at middle height. The crack is a crown of interior ray the half ray of the cylinder, and of ray external the ray of the cylinder. The loading is transitory and consists of a variation in temperature imposed by the application of conditions of Dirichlet at the two ends of the cylinder. The assumption of an adiabatic crack is made (null flow on the lips of the crack and discontinuous temperature through the crack)

Four modelings are considered:

- modeling *A* : FEM AXIS (crack with a grid)
- modeling *B* : X-FEM AXIS , crack in the middle of the elements
- modeling *C* : FEM 3D (crack with a grid)
- modeling *D* : X-FEM3D , crack in the middle of the elements

1 Problem of reference

1.1 Geometry

The structure, represented with the Figure, is a cylinder of ray $R=1\text{ m}$ and height $H=2\text{ m}$ comprising a crack planes on the section located at middle height. (included in the plan of equation $y=H/2$). The crack is emerging, and has as a geometrical support the crown of interior ray $R/2$ and of external ray R (crown filled in red with the Figure 1.1-1).

One calls "disc the lower" disc included in the plan of equation $y=0$, and "disc the higher" disc included in the plan of equation $y=H$.

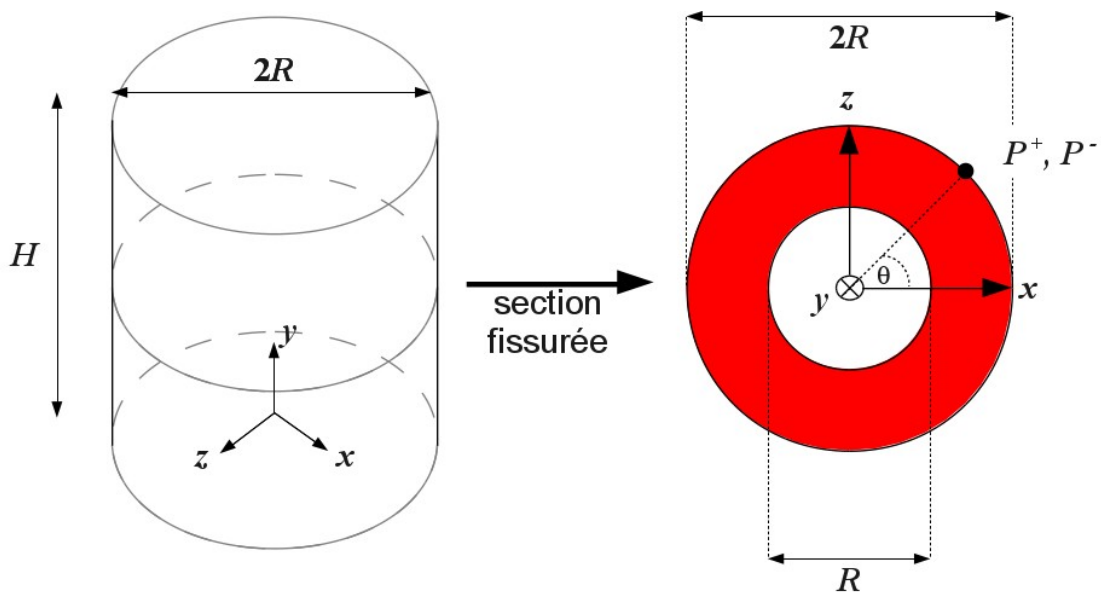


Figure 1.1-1: Geometry of the problem

Lastly, one notes $P^+(\theta)$ the point of coordinates $(R \cos \theta, H^+/2, R \sin \theta)$ (located on the upper lip), and $P^-(\theta)$ the point of coordinates $(R \cos \theta, H^-/2, R \sin \theta)$ (located on the lower lip)

1.2 Properties of material

Thermal conductivity: $\lambda = 1 \text{ W.m}^{-1} . \text{K}^{-1}$

Voluminal heat-storage capacity: $\rho C_p = 2 \text{ J.m}^{-3} . \text{K}^{-1}$

1.3 Boundary conditions and loadings

One solves the problem on the time interval $[0.s, 1.s]$ discretized in 5 pas de equal times (of duration $\Delta t = 0.2 s$). One takes the value by default in THER_LINEAIRE parameter of the theta-diagram: $\theta = 0.57$.

On the nodes of the lower disc (cf. paragraph 1.1) one imposes the slope of following temperature:

$$\text{with } t = 0.s, \bar{T}^{AB} = 10^\circ \text{C}; \quad \text{with } t = 1.s, \bar{T}^{\text{sup}} = 20^\circ \text{C}$$

On the nodes of the higher disc (cf. paragraph 1.1) one imposes the slope of following temperature:

with $t=0.s$, $\bar{T}^{\text{inf}}=20^\circ C$; with $t=1.s$, $\bar{T}^{\text{inf}}=40^\circ C$

1.4 Initial conditions

The initial state is given by solving the stationary problem with $t=0.s$ (with the boundary conditions given to the paragraph 1.3)

2 Reference solution

2.1 Method of calculating

The reference solution is obtained by refining the network of modeling A (axisymmetric classical elements with crack with a grid): regular grid composed of 1000×2000 QUAD8 (instead of 100×200 QUAD8 for the grid A)

2.2 Sizes and results of reference

One tests the temperature at the end of the last step of time ($t=1.s$) at the points $P^+(\theta)$ and $P^-(\theta)$ (see Figure 1.1-1).

| Identification | Type of reference | Value of reference |
|--------------------------|-------------------|--------------------|
| Not $P^+(\theta)$ - TEMP | 'AUTRE_ASTER' | 23,559884847913 °C |
| Not $P^-(\theta)$ - TEMP | 'AUTRE_ASTER' | 15,592470476233 °C |

The problem being axisymmetric, the values tested cannot vary with θ . One tests these values then with:

- $\theta=0$ for modelings A and B (respectively FEM AXIS and X-FEM AXIS)
- $\theta=\pi/4$ for modelings C and D (respectively FEM 3D and X-FEM 3D)

3 Modeling A

In this modeling, the classical finite element method is used, the crack is with a grid.

3.1 Characteristics of modeling

Modeling is used `AXIS` phenomenon `THERMICS`.

3.2 Characteristics of the grid

The structure is modelled by a grid `2D` regular composed of 100×200 `QUAD4`, respectively along the axes x and y . The crack is with a grid.

3.3 Sizes tested and results

One tests the temperature at the end of the last step of time ($t=1 .s$) with the nodes $P^+(0)$ and $P^-(0)$ (see Figure 1.1-1)

| Identification | Type of reference | Value of reference | Tolerance |
|----------------------------------|-------------------|--------------------|-----------|
| Not $P^+(0)$ - <code>TEMP</code> | 'AUTRE_ASTER' | 23,559884847913 °C | 0.1% |
| Not $P^-(0)$ - <code>TEMP</code> | 'AUTRE_ASTER' | 15,592470476233 °C | 0.1% |

4 Modeling B

In this modeling, the wide finite element method (X-FEM) is used.

4.1 Characteristics of modeling

Modeling is used `AXIS` phenomenon `THERMICS`.

4.2 Characteristics of the grid

The structure is modelled by a grid 2D regular composed of 101×201 QUAD4, respectively along the axes x and y . The crack is not with a grid.

4.3 Sizes tested and results

One tests the temperature at the end of the last step of time ($t=1.s$) with the nodes $P^+(0)$ and $P^-(0)$ (see Figure 1.1-1). For that one tests the field of temperature after call to the operators `POST_MAIL_XFEM` and `POST_CHAM_XFEM`.

| Identification | Type of reference | Value of reference | Tolerance |
|----------------------------|-------------------|--------------------|-----------|
| Not $P^+(0)$ - <i>TEMP</i> | 'AUTRE_ASTER' | 23,559884847913 °C | 0.1% |
| Not $P^-(0)$ - <i>TEMP</i> | 'AUTRE_ASTER' | 15,592470476233 °C | 0.1% |

5 Modeling C

In this modeling, the classical finite element method is used, the crack is with a grid.

5.1 Characteristics of modeling

Modeling is used 3D phenomenon THERMICS.

5.2 Characteristics of the grid

The structure is modelled by a grid 3D composed of 25088 HEXA8.

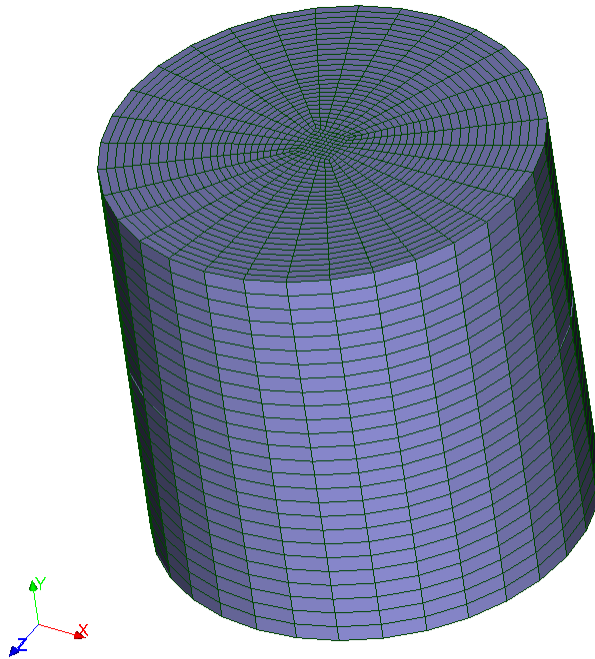


Figure 5.2-1: Grid C

5.3 Sizes tested and results

One tests the temperature at the end of the last step of time ($t=1.s$) with the nodes $P^+(\pi/4)$ and $P^-(\pi/4)$ (see Figure 1.1-1)

| Identification | Type of reference | Value of reference | Tolerance |
|-------------------------|-------------------|--------------------|-----------|
| Not $P^+(\pi/4)$ - TEMP | 'AUTRE_ASTER' | 23,559884847913 °C | 1.% |
| Not $P^-(\pi/4)$ - TEMP | 'AUTRE_ASTER' | 15,592470476233 °C | 1.% |

6 Modeling D

In this modeling, the wide finite element method (X-FEM) is used.

6.1 Characteristics of modeling

Modeling is used 3D phenomenon THERMICS.

6.2 Characteristics of the grid

The structure is modelled by a grid 3D compositionné of 25984 HEXA8. The crack is not with a grid.

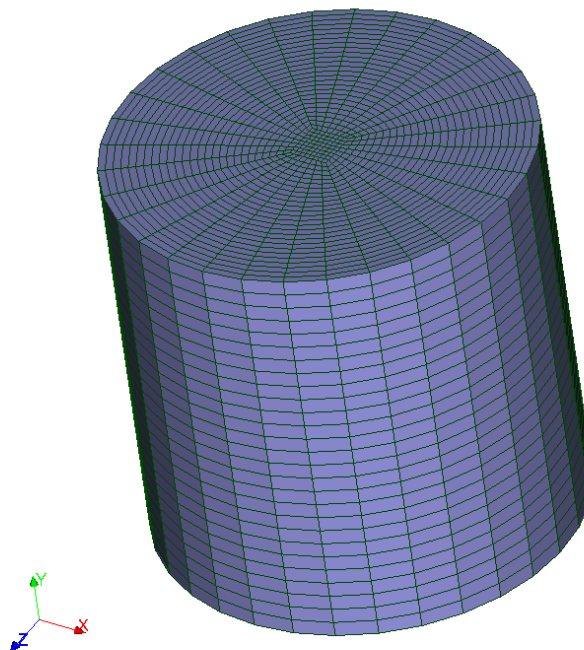


Figure 6.2-1: Grid D

6.3 Sizes tested and results

One tests the temperature at the end of the last step of time ($t=1.s$) with the nodes $P^+(0)$ and $P^-(\pi/4)$ (see Figure 1.1-1). For that one tests the field of temperature after call to the operators POST_MAIL_XFEM and POST_CHAM_XFEM.

| Identification | Type of reference | Value of reference | Tolerance |
|-------------------------|-------------------|--------------------|-----------|
| Not $P^+(\pi/4)$ - TEMP | 'AUTRE_ASTER' | 23,559884847913 °C | 1.% |
| Not $P^-(\pi/4)$ - TEMP | 'AUTRE_ASTER' | 15,592470476233 °C | 1.% |

7 Summaries of the results

The goal of this test is achieved: to validate on a simple case the axisymmetric thermal elements X-FEM in transitory linear thermics.