

ZZZZ340 – Validation of the keyword TEMP_CONTINUE for AFFE_CHAR_THER

Summary

This test validates the keyword `TEMP_CONTINUE` keyword factor `ECHANGE_PAROI` operators `AFFE_CHAR_THER` and `AFFE_CHAR_THER_F` [U4.44.02]. This keyword relates to only models X-FEM, and led to cancel all the degrees of freedom Enrichis (“Heaviside” and “ace-tip”) corresponding to the presence of the cracks given by the user under the keyword `CRACK`. The zero setting of these degrees of freedom amounts solving the equation of heat on a field not comprising these cracks.

One validates this functionality on a simple problem of stationary linear thermics in dimension 2. One considers a square plate at imposed temperature, comprising an emerging right crack laid out in the orthogonal direction with the gradient of temperature. The use of the keyword `TEMP_CONTINUE` allows not to take into account the discontinuity of the field of temperature through this crack and to be reduced to the resolution of the “healthy” problem, this last admitting an analytical solution.

One also validates in this test the calculation of the gradient of the temperature at the points of Gauss of elements X-FEM in the operator `THER_LINEAIRE` (field `TEMP_ELGA`).

Only one modeling is considered:

- modeling *A* : X-FEM2D (crack in the middle of the elements)

1 Problem of reference

1.1 Geometry

The structure 2d is a unit square: $LX = 1\text{ m}$ and $LY = 1\text{ m}$ (Figure 1.1-1).

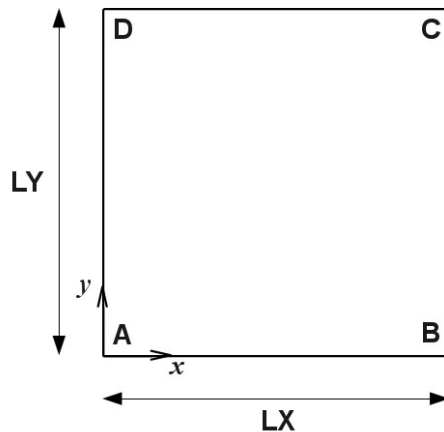


Figure 1.1-1: Geometry of the healthy plate

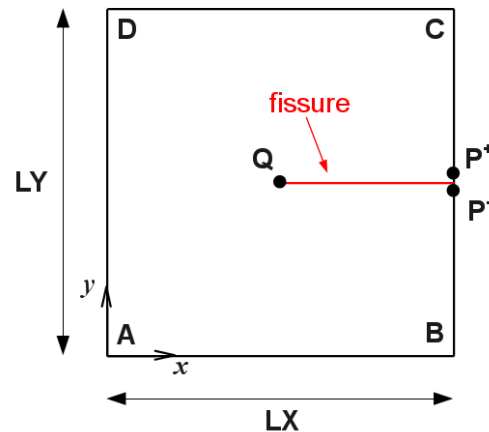


Figure 1.1-2: Geometry of the plate with fictitious crack

For the need for the CAS-test, one also considers the same field in the presence of a crack fictitious, straight lines and emerging on the right, located at middle height (Figure 1.1-2). One notes P^+ the point of coordinates $(LX, LY^+/2)$ (located on the upper lip), P^- the point of coordinates $(LX, LY^-/2)$ (located on the lower lip), and Q the point of coordinates $(LX/2, LY/2)$ (located at a peak of crack).

Note:

This crack is described as fictitious because it does not constitute part of the border of the field, and thus does not affect any the solution of the problem of reference. Its presence is only due to the data-processing validation of the functionality tested.

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

A temperature is imposed $\bar{T}^{\text{inf}} = 10^\circ\text{C}$ on the nodes of the segment AB and $\bar{T}^{\text{sup}} = 20^\circ\text{C}$ on the nodes of the segment CD (see Figure 1.1-1).

1.4 Initial conditions

Nothing (the problem is stationary)

2 Reference solution

2.1 Method of calculating

It is about an analytical solution. In this configuration the problem is unidimensional and the equation of heat is reduced to the following differential equation:

$$\frac{d^2 T}{dy^2} = 0 \text{ with the conditions } T(y=0) = \bar{T}^{\text{inf}} \text{ and } T(y=LY) = \bar{T}^{\text{sup}}$$

This equation admits the following solution:

$$T(y) = (\bar{T}^{\text{sup}} - \bar{T}^{\text{inf}}) \frac{y}{LY} + \bar{T}^{\text{inf}}$$

2.2 Sizes and results of reference

The temperature is tested at the points P^+ , P^- and Q (see Figure 1.1-2):

$$T\left(\frac{LY}{2}\right) = \frac{(\bar{T}^{\text{sup}} + \bar{T}^{\text{inf}})}{2}, \quad \text{digital application: } T\left(\frac{LY}{2}\right) = 15^\circ\text{C}$$

One also tests the two components (constant in space) of the variation in temperature:

$$\begin{aligned} \partial_x T &= 0, & \text{digital application: } \partial_x T &= 0^\circ\text{C.m}^{-1} \\ \partial_y T &= \frac{(\bar{T}^{\text{sup}} - \bar{T}^{\text{inf}})}{LY}, & \text{digital application: } \partial_y T &= 10^\circ\text{C.m}^{-1} \end{aligned}$$

Identification	Type of reference	Value of reference
Points P^+ , P^- and Q - TEMP	'ANALYTICAL'	15°C
In any point, DTX	'ANALYTICAL'	0°C.m^{-1}
In any point, DTY	'ANALYTICAL'	10°C.m^{-1}

3 Modeling a: fissures not-with a grid in dimension 2

The crack not being with a grid, the condition of exchange between the lips of the crack is applied using the keyword `CRACK` keyword factor `ECHANGE_PAROI` of the operator `AFFE_CHAR_THER` [U4.44.02].

3.1 Characteristics of modeling

Modeling is used `PLAN` phenomenon `THERMICS`. The wide finite element method (X-FEM) is used.

3.2 Characteristics of the grid

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

3.3 Sizes tested and results

The sizes below are initially tested if the loading making it possible to impose the continuity of the field temperature (keyword `TEMP_CONTINUE`) result from the operator `AFFE_CHAR_THER`, they are then tested when it results the operator `AFFE_CHAR_THER_F`.

One tests the temperature at the points P^+ , P^- and Q (see Figure 1.1-2). For that one tests the field of temperature after call to the operators `POST_MAIL_XFEM` and `POST_CHAM_XFEM`.

One tests then the two components of the gradient of the temperature stored in the field `TEMP_ELGA` in the result produced by the operator `THER_LINEAIRE`. These components are tested:

- in a point of Gauss of an element of the type "Heaviside"
- in a point of Gauss of an element of type "ace-tip"
- in a point of Gauss of an element of the type "Heaviside/ace-tip"

Identification	Type of reference	Value of reference	Tolerance
Points P^+ , P^- and Q - <code>TEMP</code>	'ANALYTICAL'	15	0.1%
In 3 points of Gauss <code>DTX</code>	'ANALYTICAL'	0	1.E-9
In 3 points of Gauss <code>DTY</code>	'ANALYTICAL'	10	0.1%

4 Summaries of the results

The goals of this test are achieved:

- to validate for models X-FEM the keyword `TEMP_CONTINUE` keyword factor `ECHANGE_PAROI` operators `AFFE_CHAR_THER` and `AFFE_CHAR_THER_F`.
- to validate the calculation of the gradient of the temperature at the points of Gauss of elements X-FEM in the operator `THER_LINEAIRE`