SSLP115 - Calculation of the rate of refund of energy of a disc fissured in the presence of initial constraints

Summary

This test makes it possible to validate the calculation of the rate of refund of energy by the method theta in the presence of a state of nonvirgin initial constraints.

Modeling a: UN embedded and fissured disc is subjected to initial stress field opening the crack. This initial stress field is identical to that generated by a heat gradient. The solution is identical to that obtained in the case of the thermal loading only, validating the taking into account of an initial state of stresses.
Modeling b: it is similar to modeling A with a crack not-with a grid (X-FEM).

1 Problem of reference

1.1 Geometry

A disc of ray is considered 100mm , embedded on its edges, and containing a horizontal crack of 23mm one of the points is in the center of the disc. Figure 1.1 present this geometry.

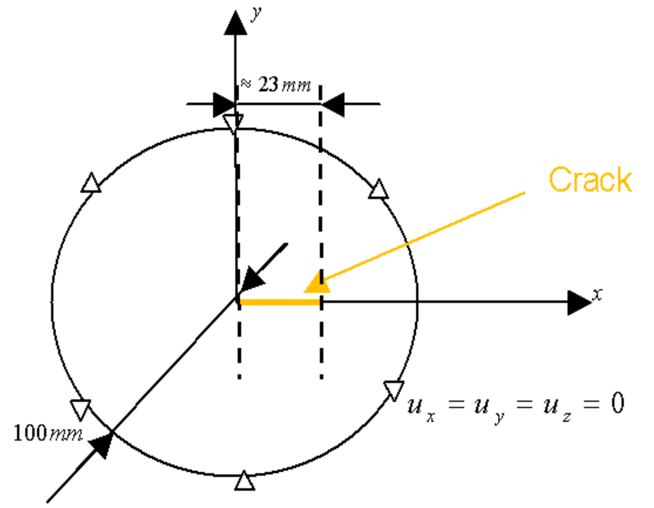

Figure 1.1 : Geometry of the disc.

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1.2 Properties of material

Young modulus: $E=210000\,MPa$
Poisson's ratio: $\nu=0,3$
Thermal dilation coefficient: $\alpha=10\text{E-}5\,K^{-1}$

1.3 Boundary conditions and loadings

The disc is completely embedded on its edge.

It is subjected to an initial stress field obtained by application of a thermal loading presenting a strong gradient according to the horizontal direction (see Figure 1.2 and Figure 1.3).

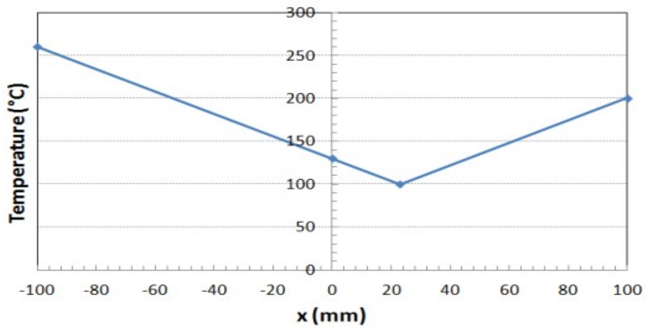

Figure 1.2 : Variation in temperature applied to the embedded disc.

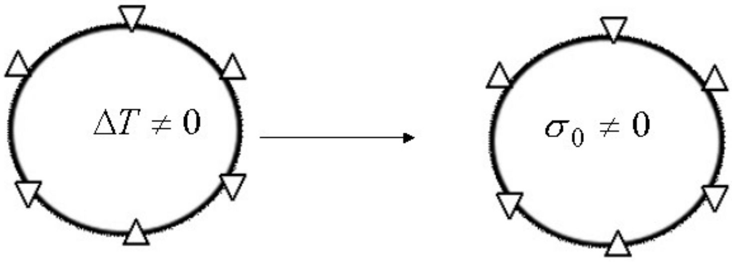

Figure 1.3 : Creation of the initial stress field.

1.4 Reference solution

The reference solution is that obtained by the application of the thermal loading directly on the disc fissured without initial state. Indeed, the behavior being elastic, the principle of superposition applies and the results in the presence of thermal loading without initial constraints and in absence of thermics with initial constraints are equivalent, as summarizes it Figure 1.4.

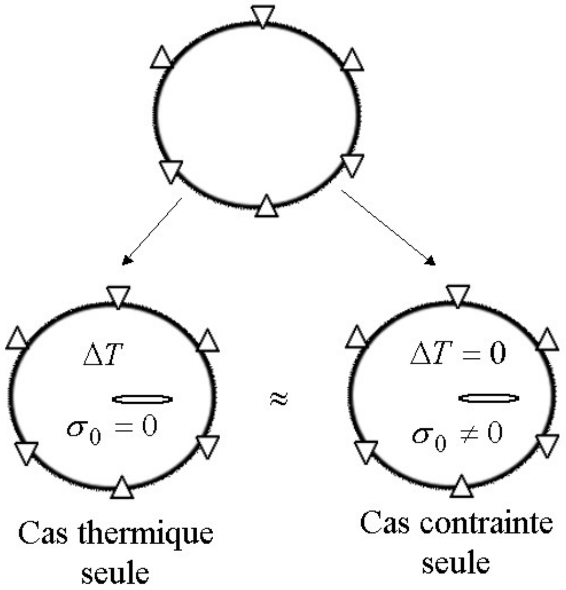

Figure 1.4 : Equivalence of the loadings.

2 Modeling A

2.1 Characteristics of the grid

The grid is quadratic radiant around the crack; it is composed of 27670 nodes forming 9519 meshs including 100 triangles allowing déraffinement. Figure 2.1 and Figure 2.2 present the grid used.

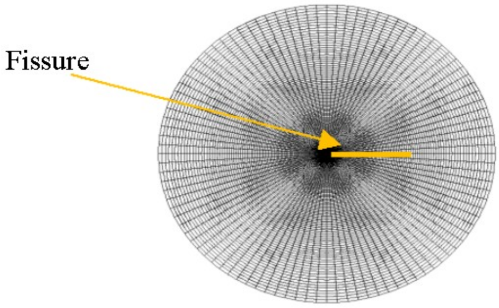

Figure 2.1 : Grid of the disc.

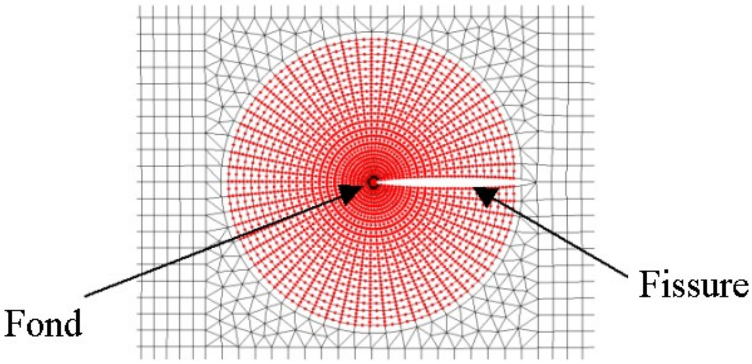

Figure 2.2 : Grid: zoom on the crack.

2.2 Calculations carried out

In order to test the various opportunities given by the order CALC_G, several configurations of calculations are put in work.

The first is the result of reference got by thermal loading without initial state. A calculation of the factors of intensity of the constraints by POST_K1_K2_K3 is also made for reference.
The others result from calculation with initial state without thermal loading; they differ by the type of initial stress field provided to the order CALC_G : at the points of gauss, with the nodes by element or the nodes. The options are also used CALC_G (rate of refund of energy) and CALC_K_G (factors of intensity of the constraints).

2.3 Sizes tested and results

2.3.1 Sizes tested

One tests the value of the rate of refund of energy result of the operator. They all must be equal except for a weak tolerance.

2.3.2 Results

Test of the rates of refund of energy and the stress intensity factors:

Identification	Reference	Type of reference	Tolerance
CALC_G			
G resulting from thermal calculation	-	'NON_REGRESSION'	-
G at the points of Gauss (GINNGA)	55,36	'AUTRE_ASTER'	2,0%
G with the nodes by element (GINELNO)	55,36	'AUTRE_ASTER'	2,0%
G with the nodes (GINNO)	55,36	'AUTRE_ASTER'	2,0%
K_I with the nodes (option CALC_K_G)	3576	'AUTRE_ASTER'	2.0 %

3 Modeling B

3.1 Characteristics of the grid

The geometry is identical to modeling A. LE grid represents the virgin part of any crack (it will be represented by method X-FEM); the grid is linear.

3.2 Calculations carried out

In order to test the various opportunities given by the order CALC_G, several configurations of calculations are put in work.

The first is the result of reference got by thermal loading without initial state.

The others result from calculation with initial state without thermal loading; they differ by the values from the rays from the crowns provided to the order CALC_G. As for modeling A, one also tests the factors of intensity of the constraints (the reference is obtained by POST_K1_K2_K3). It is noted that only the initial stress field with points of gauss was used, the definition of a stress field to the nodes not being available with X-FEM.

3.3 Sizes tested and results

3.3.1 Sizes tested

One tests the value of the rate of refund of energy result of the operator. They all must be equal except for a weak tolerance.

3.3.2 Results

Test of the rates of refund of energy and the stress intensity factors:

Identification	Reference	Type of reference	Tolerance
CALC_G			
G resulting from thermal calculation (CALC_G)	-	'NON_REGRESSION'	-
G with rays automatic (CALC_G)	55.36	'AUTRE_ASTER'	2.0%
G with R_INF = 2.4, R_SUP = 4.8 (CALC_G)	55.36	'AUTRE_ASTER'	2,0%
G with R_INF =4,228, R_SUP = 9 (CALC_G)	55.36	'AUTRE_ASTER'	3.5%
G with rays automatic (CALC_K_G)	55.36	'AUTRE_ASTER'	2.0%
G with R_INF = 2.4, R_SUP = 4.8 (CALC_K_G)	55.36	'AUTRE_ASTER'	2,0%
G with R_INF = 4.228, R_SUP = 49 (CALC_K_G)	55.36	'AUTRE_ASTER'	3.5%

K_I with rays automatic (CALC_K_G)	3574	'AUTRE_ASTER'	1.0%
K_I with R_INF = 2.4 R_SUP = 4.8 (CALC_K_G)	3574	'AUTRE_ASTER'	1.0%
K_I with R_INF =4,228, R_SUP = 9 (CALC_K_G)	3574	'AUTRE_ASTER'	1.5%

4 Summaries of the results

The case test allows a confrontation of the results got starting from a thermal field and of an initial stress field. It shows that the results are appreciably equivalent.

It will be added that this same case gives the same results with the Abaqus software in its version 6.11 (method FEM, calculation of G only).