SSNA120 – Axisymmetric test-tube notched (AE) with elements of joint and interface

Summary:

Modeling A makes it possible to make sure of nonthe regression of a functionality of Code_Aster in breaking process and to compare it with a local approach (Rousselier). The functionality tested is the cohesive law for the ductile rupture: CZM_TRA_MIX [R7.02.11].
A notched axisymmetric test-tube is requested in traction. The evolution of the force and the diametrical contraction during the propagation of the ductile rupture is calculated. The modeling of the test-tube is carried out with elements 2D (QUA8).

In addition modeling B makes it possible to validate the elements of joint in axis (AXIS_JOINT) with the law CZM_LIN_REG.

1 Problem of reference

1.1 Geometry and loading

One considers a notched axisymmetric test-tube of type $AE4$. The cohesive zone represented by elements of interface (modeling A) or elements of joint (modeling B) is positioned on the line AB .

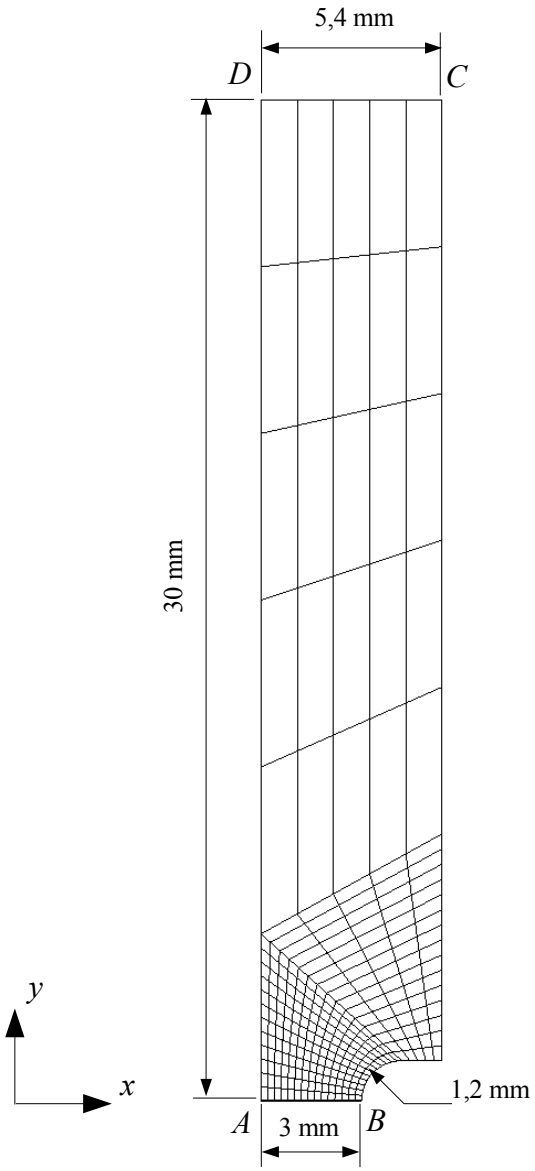

Figure 1 : Geometry of the test-tube $AE4$.

1.2 Properties of material

To describe the behavior of material of the axisymmetric test-tube (voluminal material), one uses an elastoplastic law of behaviour with an isotropic work hardening (law VMIS_ISOT_TRAC).
One takes: $E=207\ GPa$ and $\nu=0.3$ and the curve of work hardening retained is given below:

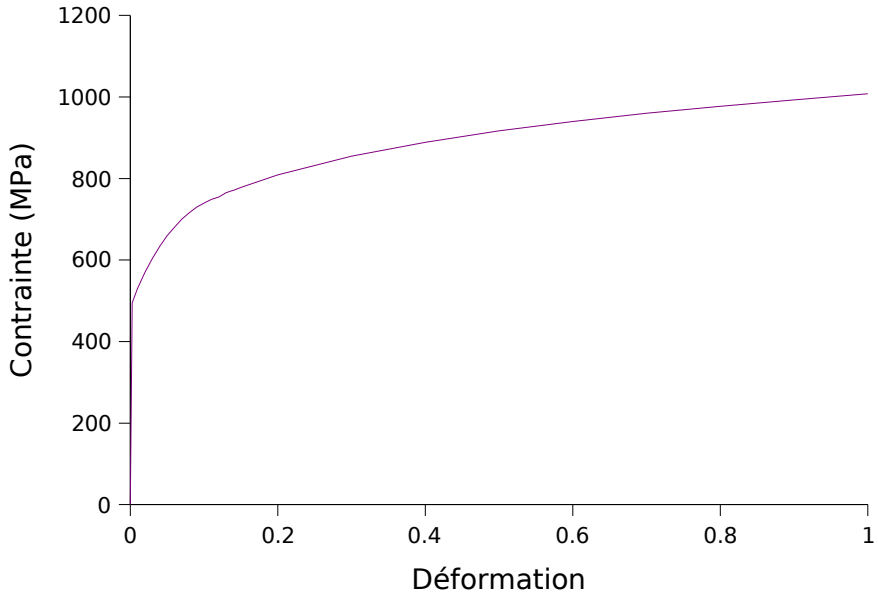

Figure 2 : Isotropic curve of work hardening of voluminal material.

One represents the crack with two different laws for modelings A and b:

Modeling a:

For the elements of interface the following parameters are used in the law CZM_TRA_MIX :
$\sigma_c = 1200 \ \ MPa$, $G_c = 130 \ \ MPa \cdot mm$, $\delta_e = 0.01 \ \ mm$, $\delta_p = 0.07 \ \ mm$, $\delta_c = 0.157 \ \ mm$,
The law which results from this is schematized below.

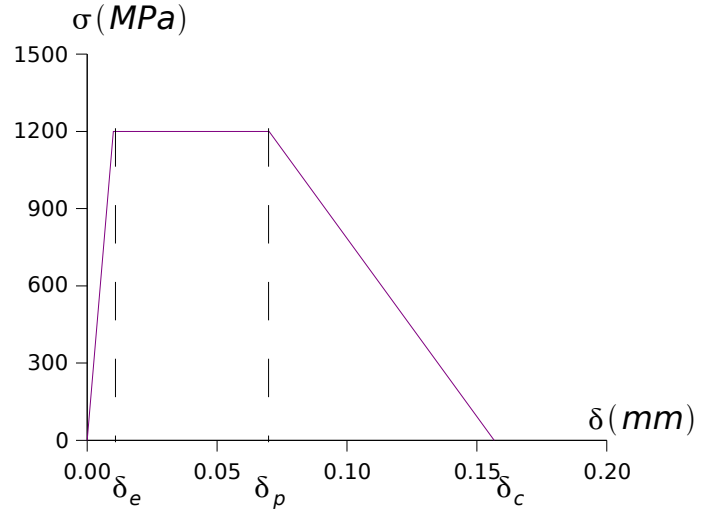

Figure 3 : Law of behavior of the elements of interface.

NB: Only half of the crack is modelled thanks to the symmetry of the problem, the tenacity of material is of $2G_c$.

Modeling b:
For the elements of joint the following parameters are used in the law CZM_LIN_REG:
$\sigma_c = 1200 \ \ MPa$, $G_c = 130 \ \ MPa \cdot mm$, $pena\ adherence = 1.E-5$

NB: Only half of the crack is modelled thanks to the symmetry of the problem, the tenacity of material is of $2G_c$.

1.3 Boundary conditions and loading

While referring to figure 1, the boundary conditions are the following ones:

- displacement in X blocked on the line AD,
- imposed displacement l according to the direction Y on the line DC.

Evolution of displacement l in the course of time is given in the following table:

Time $[s]$	0	1
Displacement l $[mm]$	0	0.5

The cohesive zone is represented by the elements of interface on the line AB. The upper lip of the elements of interface is called AB and the lower lip is called $A'B'$. The boundary conditions on the elements of interface are:

- displacement in X imposed on the lips AB and $A'B'$: $DX_{AB} = DX_{A'B'}$
- displacement in Y blocked on the line $A'B'$.

2 Reference solution

2.1 Sizes and results of reference

The displacement of the node B according to X (DEPL) and forces it applied to the test-tube (REAC_NODA) were calculated.

For modeling a:
A comparison is carried out with two different calculations:
- a former execution of Code_Aster with the law CZM_TRA_MIX, it is about a case test of not-regression;
- a former execution of Code_Aster where the ductile rupture is modelled with the model of Rousselier by the law ROUSS_PR.

In the case of modeling with the model of Rousselier, the parameters retained for this model are the following: $D=2$, $SIGM_1=460$ and $f0=0,0005$

For modeling b: one carries out only tests of not-regression.

3 Modeling A

3.1 Characteristics of modeling

The modeling of ductile rupture is carried out with modeling AXIS_INTERFACE and the law CZM_TRA_MIX. The elements of volume are modelled with the model AXIS.

3.2 Characteristics of the grid

The grid of entry is linear. It is transformed into a quadratic grid by LINE_QUAD in CREA_MAILLAGE.
After the transformation its characteristics are the following ones:
Many nodes: 962
Many elements: 280 QUAD8.
Many elements of interface: 15 QUAD8.

3.3 Sizes tested and results

Test of nonregression : diametrical contraction ($-2\times DX$ point B), force of traction (the resultant DY of REAC_NODA on CD multiplied by 2π) according to the displacement of traction DY (on CD).

For a displacement of $0,3\,mm$ according to Y on CD

Size tested	Code_Aster	Tolerance (%)
Contraction (mm)	0.605676	0.10
Force (kN)	28.8696	0.10

For a displacement of $0,4\,mm$ according to Y on CD

Size tested	Code_Aster	Tolerance (%)
Contraction (mm)	0.931629	0.10
Force (kN)	23.6023	0.10

Test of nonregression on the calculation carried out with the model of Rousselier : diametrical contraction ($-2\times DX$ point B), force of traction (the resultant DY of REAC_NODA on CD multiplied by 2π) according to the displacement of traction (DY on CD).

For a displacement of $0,2\,mm$ according to Y on CD

Size tested	Code_Aster	Rousselier	Error (%)
Contraction (mm)	0.333202	0.349885	4.8
Force (kN)	29.3851	29.3597	0,087

For a displacement of $0,3\,mm$ according to Y on CD

Size tested	Code_Aster	Rousselier	Error (%)
Contraction (mm)	0.605676	0.620591	2.4
Force (kN)	28.8696	28.6069	0.92

For a displacement of $0,4\,mm$ according to Y on CD

Size tested	Code_Aster	Rousselier	Error (%)
Contraction (mm)	0.931629	0.954683	2.4

Force (kN)	23.5744	22.6731	01/04/00

4 Modeling B

4.1 Characteristics of modeling

Modeling into fragile is carried out with modeling AXIS_JOINT and the law CZM_LIN_REG. The elements of volume are modelled with the model AXIS.

4.2 Characteristics of the grid

The grid is linear.
Many elements: 280 QUAD4.
Many elements of interface: 15 QUAD4.

4.3 Sizes tested and results

Test of nonregression : diametrical contraction ($-2\times DX$ point B), force of traction (the resultant DY of REAC_NODA on CD multiplied by 2π) according to the displacement of traction DY (on CD).

For a displacement of $0,6\,mm$ according to Y on CD

Size tested	Code_Aster	Tolerance (%)
Contraction (mm)	0.253835	0.10
Force (kN)	25.18191	0.10

For a displacement of $0,8\,mm$ according to Y on CD

Size tested	Code_Aster	Tolerance (%)
Contraction (mm)	0.254455	0.10
Force (kN)	7.112202	0.10

4 Summary of the results

Tests of nonregression are carried out for two modelings. One carries out besides the tests of comparison with the model of Rousselier for modeling A.