SSNP131 - Identification of the energy parameter Gp in 2D and 3D

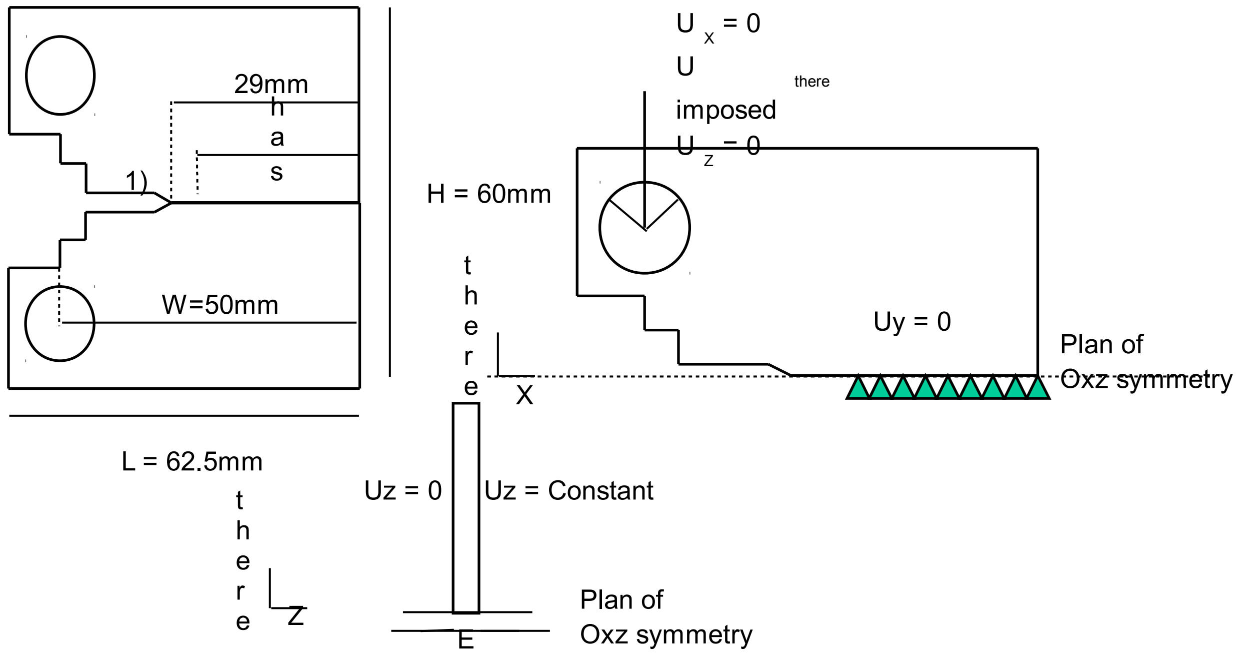
Summary

This test of nonlinear quasi-static mechanics makes it possible to present the calculation of the parameter G_p resulting from the energy approach from the elastoplastic rupture and the identification from the breaking values corresponding to values of experimental tenacity given. It requires to represent the crack by a notch and to finely net the vicinity of the bottom of notch. It also requires to calculate elastic energy on the zone of virtual propagation of the notch, cut out in “chips”.

Modeling A is carried out with elements $2D$ quadratic, in plane deformation. The grid represents the zones known as chips; the calculation of the parameter is carried out by using the properties of the grid (`POST_GP` and `CALC_GP`) or by automatic creation of these zones (`CALC_GP`).
Modeling B is identical to modeling A, but uses an unspecified grid; only the automatic definition of the chips is used (`CALC_GP`).

1 Problem of reference

1.1 Geometry



A test-tube is considered $CT25$ with a length of ligament: $a=27.5\,mm$ ($a/W=0.55$). Along the axis z, the thickness is $e=1\,mm$. The test-tube $CT25$ is modelled in plane deformations. By reason of symmetry, half of this one is represented in $2D$.

1.2 Material properties

Young modulus: 214100 Mpa
Poisson's ratio: $\nu=0.3$. The traction diagram used is presented in the following table:

ϵ	$\sigma(\mathrm{MPa})$
0.003439678	740.6632663
0.004628373	842.148772
0.00607988	876.3117064
0.007654628	895.2063119
0.010417548	911.0718694
0.014178015	925.022448
0.017543214	935.2135771
0.021942493	945.6948965
0.027416704	960.732311
0.033866984	975.8041996
0.040205805	988.2450325
0.046616375	1000.143035
0.052903597	1010.004051
0.058235889	1017.5664

Table 1.1

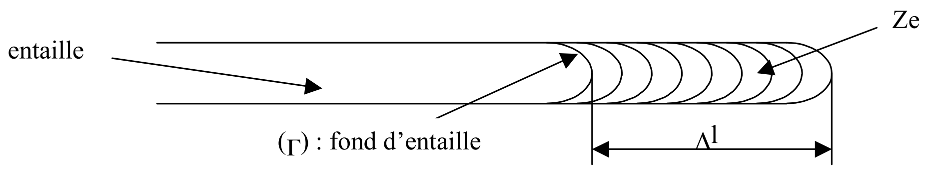
1.3 Boundary conditions and loadings

LE loading is of standard displacement imposed in a point located at the center of the pin which is modelled by four indeformable angular sectors. Half of the test-tube being modelled, a condition of symmetry is applied to the ligament ($y=0$).

2 Reference solution

2.1 Method of calculating used for the reference solution in 2D

One uses the energy method of the elastoplastic rupture based on the parameter Gp [1], [2].
The bottom of notch is made of a half-circle of ray R. The zone Ze of length Δl corresponds to the virtual propagation of the notch and is cut out in "chips".



The evolution of the quantity at every moment there is determined $Gp(\Delta l)$ defined by:

$$Gp(\Delta l)=2[W_{elas}^{traction}(\Delta l)]/\Delta l$$

where $W_{elas}^{traction}(\Delta l)$ is the elastic energy of traction calculated on the zone Ze. One must then calculate the maximum of this quantity compared to Δl, that one calls " Gp ".

$$Gp=\underset{\Delta l}{Max}\{Gp(\Delta l)\}$$

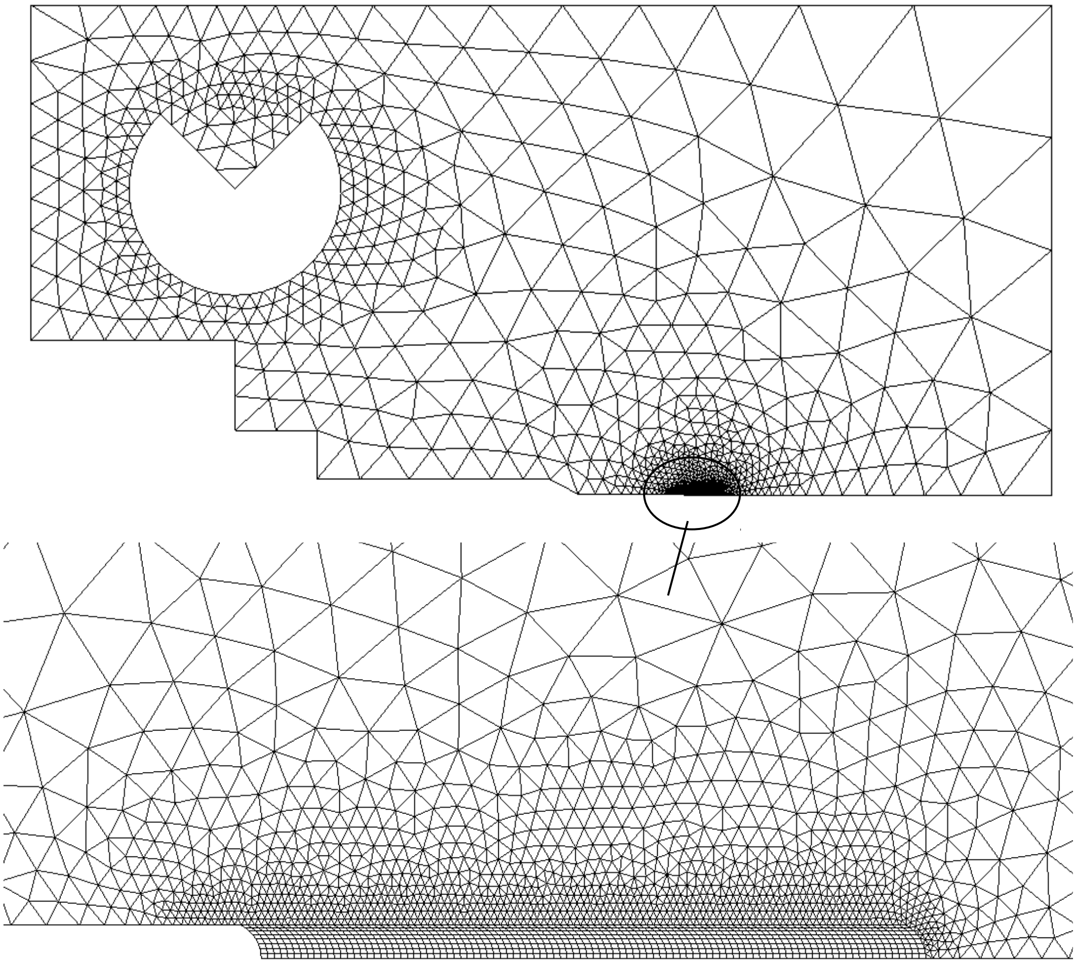
The moment criticizes where the propagation of the defect will start is then that where tenacity $Kj=Kj_{crit}$. It is said whereas Gp reached the value criticizes " Gpc ".

2.2 Bibliographical references

1) WADIER Y.: "Brief presentation of the energy approach of the elastoplastic rupture applied to the rupture by cleavage", Notes EDF R & D HT-64/03/001/A, January 2003.
2) WADIER Y., LORENTZ E.: "Breaking process in the presence of plasticity: modeling of the crack by a notch". C.R.A.S.T. 332, IIb series, 2004.

3 Modeling A

3.1 Characteristics of modeling



The crack is modelled by a notch of ray 100 microns. The zone Ze of $2\,mm$ of length is divided into layers of 20 microns thickness elements (also called “chips”).

3.2 Characteristics of the grid

Many nodes: 9368

Many meshs and types: 3350 `TRIA6`, 800 `QUAD8`

3.3 Sizes tested and results

3.3.1 Values tested

With the operator `CALC_GP` and definition of the chips by the grid:

Identification	***Reference Aster***	***Tolerance (%)***
G_P at moment 4 with chip 8	0.022692041	0,010
G_P at moment 40 with chip 3	0.667072167	0,010

With the operator `CALC_GP` and automatic definition of the chips

Identification	***Reference Aster***	***Tolerance (%)***
G_P at moment 4 with chip 8	0.0234148559	0,010
G_P at moment 40 with chip 3	0.674949376	0,010

4 Modeling B

4.1 Characteristics of modeling

This modeling is two-dimensional, in plane deformations. One uses an initial grid of CT. The crack is modelled there by a notch of ray 100 microns, with a fairly fine grid. The initial grid comprises 2937 nodes and 1377 elements. It is visible on the Figure 4.1 and 4.2.

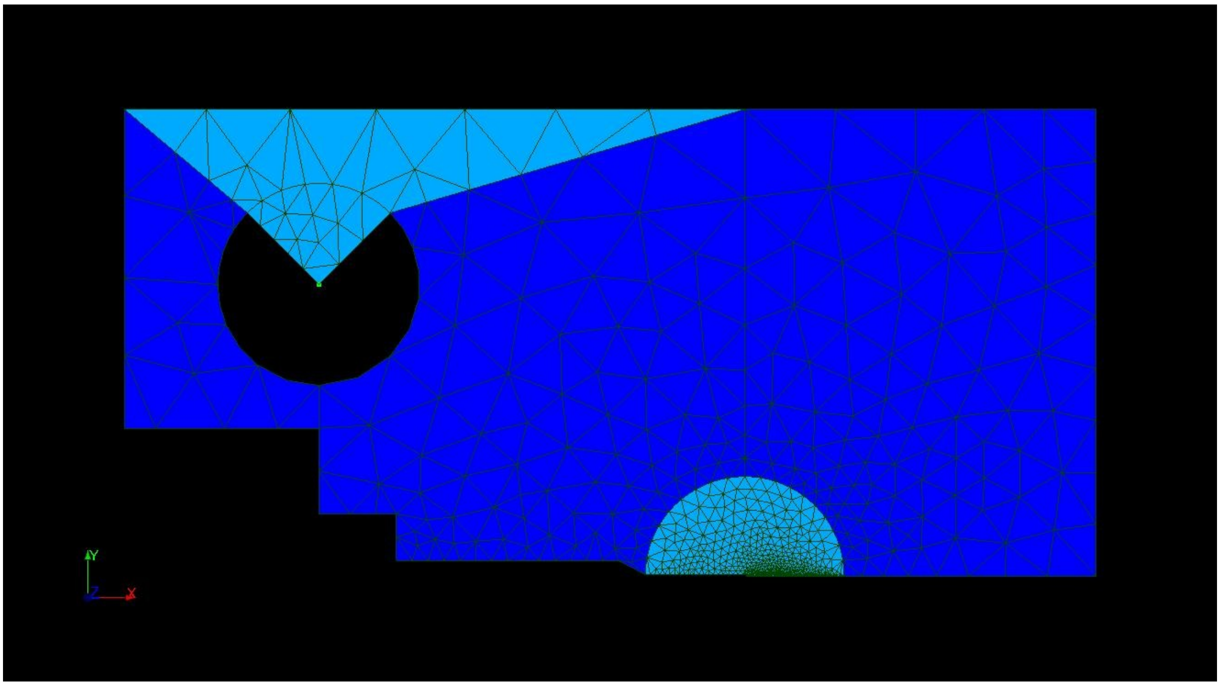


Figure 4.1 : Overall picture of the initial grid.

Figure 4.2 : Zoom on the notch of the initial grid.

The grid is then refined with order RAFF_GP on a zone of 10 chips of 20 microns (either on 0,2mm). The Figure presents the grid finally obtained, comprising 4920 nodes for 1377 elements.

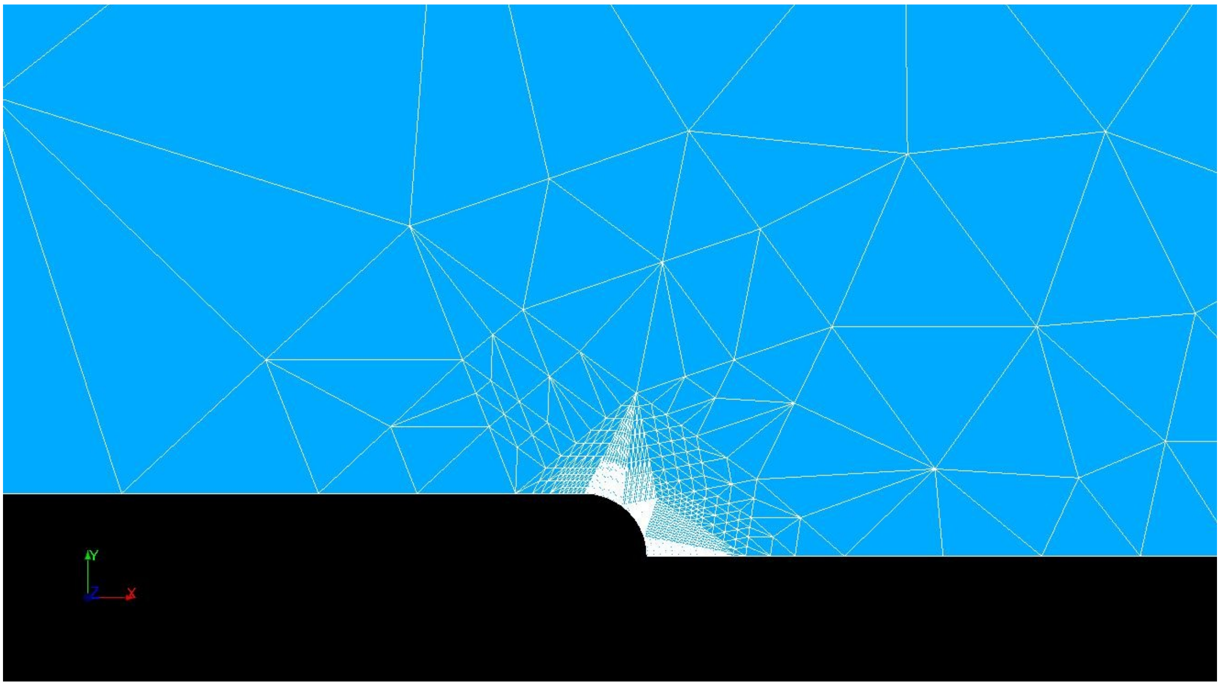


Figure 4.3 : Zoom on the notch of the refined grid.

4.2 Sizes tested and results

With the operator `CALC_GP` and automatic definition of the chips by the grid:

Identification	*Reference Aster*	*Tolerance (%)*
G_P at moment 40 with chip 3	0.7171792604019	0,010

The differences noticed between the various possibilities in calculation are due to the choice of the elastic free energy used either in the case of an explicit grid of the chips or in the case of the free grid, respectively $W_{elas}^{traction}(\Delta S)$ and $W_{elas}(\Delta S)$. In the case of the grid clarifies chips ($W_{elas}^{traction}(\Delta S)$), where one removes the participation of the spherical compression and of compression according to each clean directions of deformation, elastic energy will be modified in an elastic energy of traction and by definition $W_{elas}^{traction}(\Delta S) < W_{elas}(\Delta S)$.

5 Summary of the results

Lbe tests are validated with a lower deviation than 2nd-04%.
One notes moreover one great coherence of the results $2D$.