HSNV105 - Plate in tension-shears: élasto-viscoplasticity with metallurgy

Summarized:

This test of nonlinear quasi-static mechanics consists in charging in tension-shears a square plate. It is largely inspired by tests SSNP14 [V6.03.014] and SSNP15 [V6.03.015] from guide VPCS. The behavior model which one validates here is a élasto-viscoplastic behavior model which one introduced into *Code_Aster* for the mechanical analyzes taking into account the metallurgy. It is an isotropic model of Norton-Hoff type with an additive hardening which can be restored.
The temperature and the metallurgical state are constant, one thus considers neither plasticity of transformation nor metallurgical restoration of hardening. One does not consider either viscous restoration of hardening.

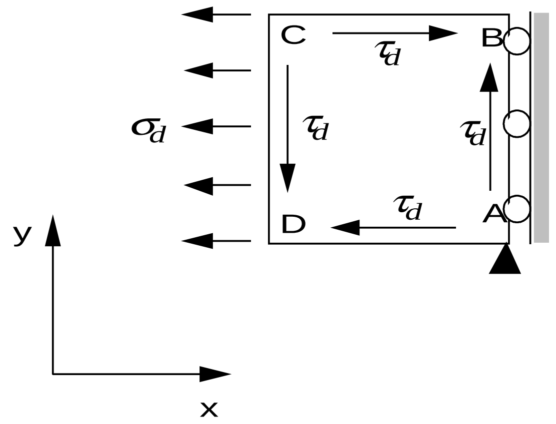
The plate is modelled by a voluminal element (HEXA8).

The results got by *Code_Aster* are very close to the analytical solution of reference (variation $< 0.04\%$).

1 Problem of reference

1.1 Geometry

Plates Relation



1.2 square

Material properties isotropic

$E=195\,000\,MPa$

$\nu=0.3$

Elasticity of comprise élasto-viscoplastic.

$\eta=600\,MPa.s^{n}$

$n=3.5$

$\sigma_c=0.\,MPa$

$c=0.$ (not of viscous restoration of hardening)

$m=20.$

1.3 Boundary conditions and loadings

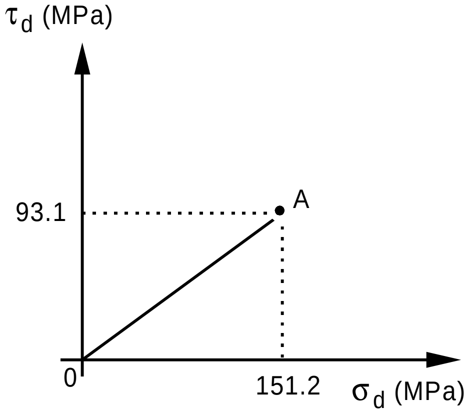
In A : $u_x=u_y=0$

On the side AB : $u_x=0$

One uniformly imposes on the structure a temperature $T=750\,°C$
and the TRC is such as the metallurgical state corresponding to this temperature is 100% ferritic.

Loading:

Way OA below of $t=0$ with $t=10\,s$ then maintenance in A until $t=60\,s$



2 Reference solution

2.1 Method of calculating used for the reference solution

being given nature of the requests, the solution (forced σ, strains ε and cumulated plastic strain p) is homogeneous. In a point of the way of loading OA, one obtains:

$$\sigma_{xx} = \sigma_d$$
$$\sigma_{xy} = \tau_d$$
$$\sigma_{eq} = \sqrt{\sigma_d^2 + 3\tau_d^2}$$

The elastic strain is worth:

$$\varepsilon^e{}_{xx} = \frac{1}{E}\,\sigma_d$$
$$\varepsilon^e{}_{xy} = \frac{1+\nu}{E}\,\tau_d$$
$$\varepsilon^e{}_{yy} = -\nu\,\varepsilon^e{}_{xx}$$

The viscoplastic strain is worth:

si $\sigma_{eq} - R - \sigma_c > 0$:

$$\dot{\varepsilon}_{xx}^{vp} = \dot{p}\,\frac{\sigma^D}{\sigma_{eq}}$$
$$\dot{\varepsilon}_{xy}^{vp} = \frac{3}{2}\,\dot{p}\,\frac{\tau^D}{\sigma_{eq}}$$
$$\dot{\varepsilon}_{yy}^{vp} = -\frac{1}{2}\,\varepsilon_{xx}^{vp}$$

avec $\dot{p} = \left(\frac{\sigma_{eq} - R - \sigma_c}{\eta}\right)^n$ où $R = R_0 p$

si $\sigma_{eq} \le \sigma_c$: $\dot{p} = 0$ $\dot{\varepsilon}_{xx}^{vp} = 0$ $\dot{\varepsilon}_{xy}^{vp} = 0$ $\dot{\varepsilon}_{yy}^{vp} = 0$

Lastly, the total deflection is:

$$\varepsilon_{xx} = \varepsilon^e{}_{xx} + \varepsilon^{vp}{}_{xx}$$
$$\varepsilon_{xy} = \varepsilon^e{}_{xy} + \varepsilon^{vp}{}_{xy}$$
$$\varepsilon_{yy} = \varepsilon^e{}_{yy} + \varepsilon^{vp}{}_{yy}$$

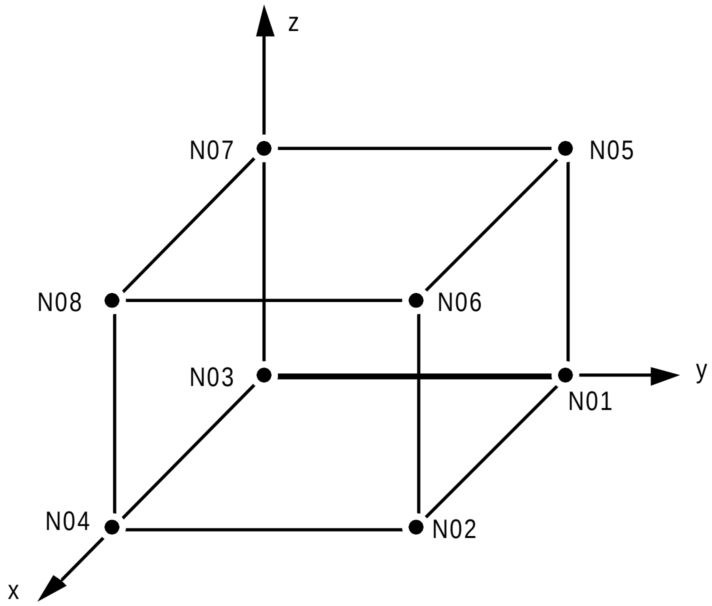
The reference solution is obtained by means of a program written in FORTRAN which carries out a resolution step by step of the problem with an implicit diagram of discretization.

2.2 Results of reference

One will be interested in the values of the stresses and of the strains at the point A of the way of loading at times $t=10\,s$ and $t=60\,s$

3 Modelization A

3.1 Characteristic of the modelization



the loading and the boundary conditions are modelled by:

DDL_IMPO: (THE NODE IS OUTSIDE THE FIELD OF DEFINITION WITH A RIGHT PROFILE OF THE EXCLU TYPE NODE: N04, DX: 0. , DY: 0.)
DDL_IMPO: (THE NODE IS OUTSIDE THE FIELD OF DEFINITION WITH A RIGHT PROFILE OF THE EXCLU TYPE NODE: N08, DX: 0. , DY: 0. , DZ: 0.)
DDL_IMPO: (THE NODE IS OUTSIDE THE FIELD OF DEFINITION WITH A RIGHT PROFILE OF THE EXCLU TYPE NODE: N02, DX: 0.)
DDL_IMPO: (THE NODE IS OUTSIDE THE FIELD OF DEFINITION WITH A RIGHT PROFILE OF THE EXCLU TYPE NODE: N06, DX: 0.)
FORCE_NODALE: (THE NODE IS OUTSIDE THE FIELD OF DEFINITION WITH A RIGHT PROFILE OF THE EXCLU TYPE NODE: (N01 N03 N05 N07), FX: $-\frac{1}{4}\sigma_d(t)$, FY: $-\frac{1}{4}\tau_d(t)$)
FORCE_NODALE: (THE NODE IS OUTSIDE THE FIELD OF DEFINITION WITH A RIGHT PROFILE OF THE EXCLU TYPE NODE: (N03 N04 N07 N08), FX: $-\frac{1}{4}\tau_d(t)$)
FORCE_NODALE: (THE NODE IS OUTSIDE THE FIELD OF DEFINITION WITH A RIGHT PROFILE OF THE EXCLU TYPE NODE: (N02 N04 N06 N08), FY: $\frac{1}{4}\tau_d(t)$)
FORCE_NODALE: (THE NODE IS OUTSIDE THE FIELD OF DEFINITION WITH A RIGHT PROFILE OF THE EXCLU TYPE NODE: (N01 N02 N05 N06), FX: $\frac{1}{4}\tau_d(t)$)

One imposes moreover one uniform temperature on the structure being worth at any moment: $T=750°C$ using operator CREA_CHAMP.

3.2 Characteristics of the mesh

Many nodes: 8

Number of meshes and type: 1 HEXA8

3.3 Quantities tested and Urgent

Variable	results (s)	Standard of Reference	Reference	% tolerance
ε_{xx}	10	SOURCE_EXTERNE	2.4333E-2	0.10
ε_{yy}	10	SOURCE_EXTERNE	– 1.2011E-2	0.10
ε_{xy}	10	SOURCE_EXTERNE	2.2379E-2	0.10
ε_{xx}	30	SOURCE_EXTERNE	5.2103E-2	0.10
ε_{yy}	30	SOURCE_EXTERNE	– 2.5896E-2	0.10
ε_{xy}	30	SOURCE_EXTERNE	4.8027E-2	0.10
ε_{xx}	60	SOURCE_EXTERNE	5.9557E-2	0.10
ε_{yy}	60	SOURCE_EXTERNE	– 2.9624E-2	0.10
ε_{xy}	60	SOURCE_EXTERNE	5.4912E-2	0.10

4 Summary of the results

the results got with *Code_Aster* are close to those of the reference solution (variations $< 0.05\%$)