HSNV136 - Degeneration of the model META_LEMA_ANI in law of Norton: simple traction in great deformations

Summary:

This test consists in subjecting to a traction according to its axis a cylindrical bar whose behavior is viscoplastic, by modelling it in two different but equivalent ways: maybe with the model META_LEMA_ANI that one makes "degenerate" into a law of Norton by choosing in a judicious way the coefficients (modeling A), is with a law of Norton itself (modeling B).

The loading is done in imposed displacement and requires the reactualization of the geometry (great deformations, keyword PETIT_REAC). One must then obtain the same answer for two modelings A and B.

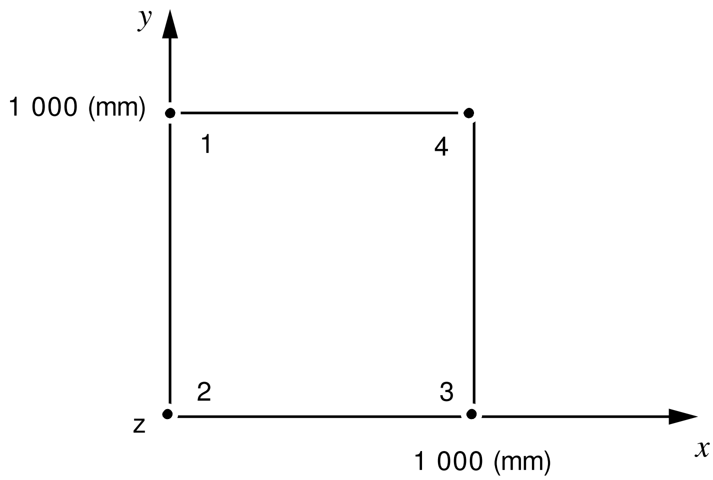
Moreover, modeling C is introduced in order to validate the great deformations logarithmic curves (keyword GDEF_LOG) for this behavior.

Lastly, modeling D makes it possible to validate the taking into account by the order SIMU_POINT_MAT metallurgical data with the law META_LEMA_ANI.

The bar is modelled by a quadrangular element QUAD4, into axisymmetric.

1 Problem of reference

1.1 Geometry



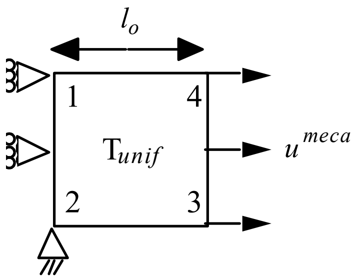
1.2 Properties of material

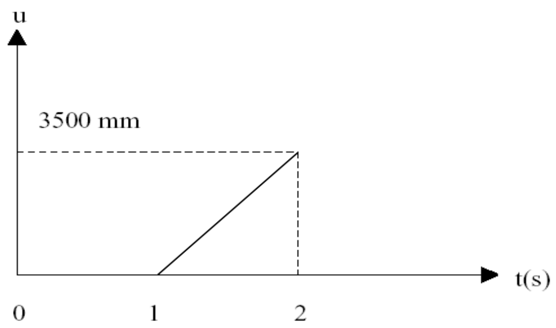
The material obeys a law of viscoplastic behavior of Norton (typical case of the law of Lemaître, where the parameter UN_SUR_M is null, confer [R5.03.08]), whose parameters are:

Young modulus: $E=80\,000\,MPa$
Poisson's ratio: $\nu=0.35$
$n=4.39$
$K=\frac{1}{0.003944}\,MPa.s^{-1}$

1.3 Boundary conditions and loadings

The bar, initial length I_0, blocked in the direction Ox on the face $[1,2]$ is subjected to a uniform temperature T and with a mechanical displacement of traction u^{meca} on the face $[3,4]$. The sequences of loading are the following ones:





Temperature of reference: $T_{réf}=700°C$.

Note:

The uniform temperature imposed on the element, constant in the course of time and equal to the temperature of reference, is only used to make function the model META_LEMA_ANI. There is no thermal dilation.

2 Reference solution

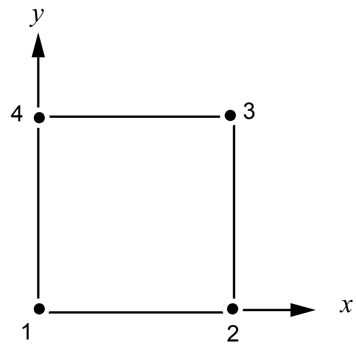
Validation of the law META_LEMA_ANI is done by the comparison of two modelings A and B. Each of two modelings thus constitutes a reference solution for the other.

The validation of this law in great deformations logarithmic curves is done by intercomparison of two modelings A and C.

3 Modeling A

3.1 Characteristics of modeling

Modeling $2D$ axisymmetric, `AXIS` :



Boundary conditions:

$N1 \ : \ u_y=0$

$N2 \ : \ u_y=0$

Loading:

Traction on the face $[3\ 4]$ (mesh `SEG2`)
Assignment of the same temperature on all the nodes
The full number of increments is of 501 (1 increment enters $t=0\text{s}$ and $t=1\text{s}$, 500 increments enters $t=1\text{s}$ and $t=2\text{s}$)

Convergence is carried out if the residue `RESI_GLOB_RELA` is lower or equal to 10^{-6} .

Behavior:

One carries out a metallurgical calculation on the first increment (which gives 100% of cold phase).

For mechanical calculation, one uses the keywords `ELAS_META` and `META_LEMA_ANI`, with the following parameters (see [R4.04.05]):

$E=80\,000\ MPa$
$\nu=0.35$
$\alpha_f=0.$
$\alpha_c=0.$
$a_1=2.40\ MPa$
$m_1=0.$
$n_1=4.40$
$Q_1=19900.K$
$M_{rrrr}^1=1.$
$M_{\theta\theta\theta\theta}^1=1.$
$M_{zzzz}^1=1.$
$M_{r\theta r\theta}^1=0.75$
$M_{rzrz}^1=0.75$

$M^{1}_{\theta z \theta z}=0.75$

Parameters corresponding to phases 2 and 3 (respectively mixture $\alpha\beta$ and phase heat) do not play of role and are taken unspecified.

3.2 Characteristics of the grid

Many nodes: 4
Many meshs: 2
1 QUAD4
1 SEG2

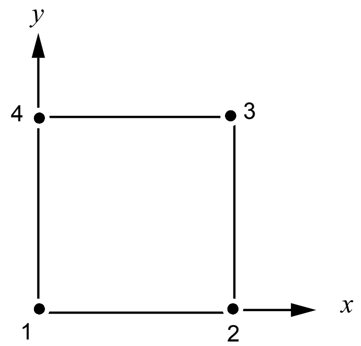
3.3 Sizes tested and results

Identification	Reference
$t=2$ Displacement DX ($N3$)	-527.4259
$t=2$ Constraints $SIGYY$ ($PG1$)	236.6860
$t=2$ Variable p $VARI$ ($PG1$)	1.4984

4 Modeling B

4.1 Characteristics of modeling

Modeling $2D$ axisymmetric, `AXIS` :



Boundary conditions:

$N1$: $u_y=0$
$N2$: $u_y=0$

Loading:

Traction on the face $[3\,4]$ (mesh `SEG2`)
Assignment of the same temperature on all the nodes
The full number of increments is of 501 (1 increment enters $t=0\text{s}$ and $t=1\text{s}$, 500 increments enters $t=1\text{s}$ and $t=2\text{s}$)

Convergence is carried out if the residue `RESI_GLOB_RELA` is lower or equal to 10^{-6}.

Behavior:

The keywords are used `ELAS` and `LEMAITRE`, with the following parameters:

$$E=80\,000\;MPa$$
$$\nu=0.35$$
$$n=4.39$$
$$\frac{1}{K}=0.003944$$
$$\text{UN\_SUR\_M}=0.$$

4.2 Characteristics of the grid

Many nodes: 4
Many meshs: 2
1 `QUAD4`
1 `SEG2`

4.3 Sizes tested and results

Identification	Reference	Tolerance
$t=2$ Displacement DX ($N3$)	-527.4259	1.0%
$t=2$ Constraints $SIGYY$ ($PG1$)	236.6860	1.0%
$t=2$ Variable p $VARI$ ($PG1$)	1.4984	1.5%

5 Modeling C

5.1 Characteristics of modeling

Modeling $2D$ axisymmetric, AXIS , identical to modeling A. Seul changes the model of great deformations: one uses here GDEF_LOG

5.2 Characteristics of the grid

As for modeling A.

5.3 Sizes tested and results

Identification	Reference	Tolerance
$t=2$ Displacement DX ($N3$)	-527.4259	1.0%
$t=2$ Constraints $SIGYY$ ($PG1$)	236.6860	1.0%
$t=2$ Variable p $VARI$ ($PG1$)	1.4984	1.5%

6 Modeling D

6.1 Characteristics of modeling

Modeling $2D$ axisymmetric, AXIS , identical to modeling A. Seuls change the order used and the moment of end: one uses here SIMU_POINT_MAT and one stops with $t=1.03$.

6.2 Characteristics of the grid

As for modeling A.

6.3 Sizes tested and results

Identification	Reference
$t=1.03$ Deformation $EPYY$ ($PG1$)	0,105
$t=1.03$ Constraints $SIGYY$ ($PG1$)	337.24
$t=1.03$ Variable p $VARI$ ($PG1$)	0.10078

7 Summary of the results

The results found with these three modelings are very close, the relative error being lower than 0.02% .