

## HSNV136 - Degeneration of the model META\_LEMA\_ANI in law of Norton: simple traction in great deformations

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### 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.

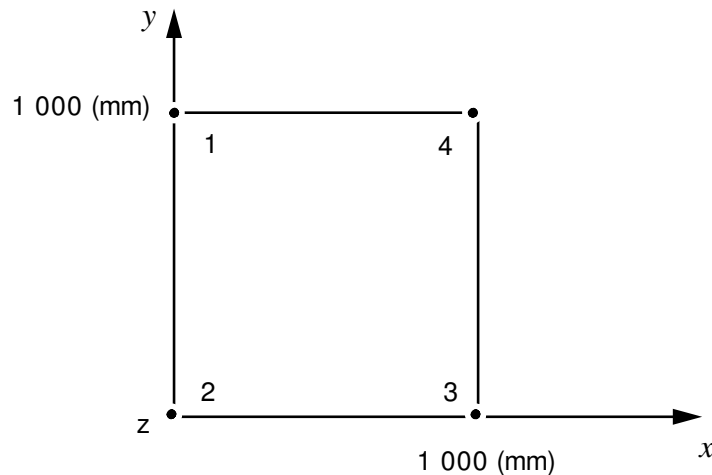
Moreover, modeling C is introduced in order to validate the great deformations logarithmic curves (keyword GDEF\_LOG) for this behavior.

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:  $E = 80\,000\text{ MPa}$

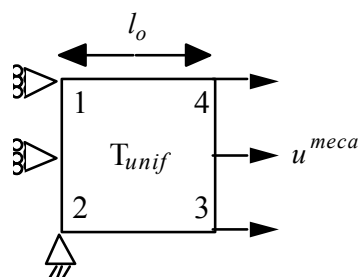
Poisson's ratio:  $\nu = 0.35$

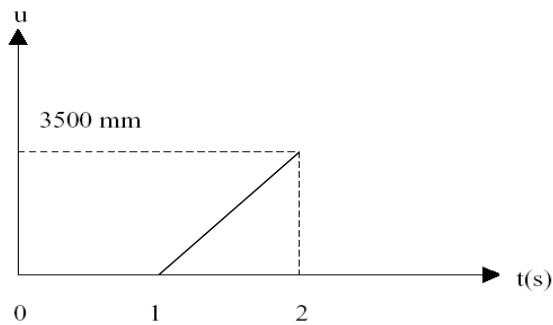
$n = 4.39$

$$K = \frac{1}{0.003944} \text{ MPa.s}^{-1}$$

### 1.3 Boundary conditions and loadings

The bar, initial length  $l_0$ , 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:  $T_{réf} = 700^{\circ}C$ .

**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

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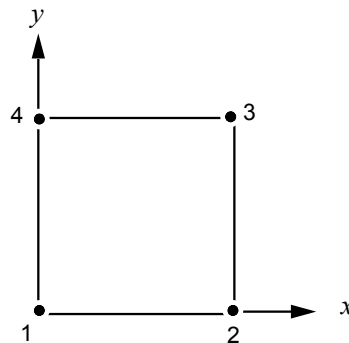
Validation of the law META\_LEMA\_ANI is done by the comparison of two modelings A and B. Each of two modelings thus constitutes a reference solution for the other.

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  $t=0s$  and  $t=1s$ , 500 increments enters  $t=1s$  and  $t=2s$ )

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]):

$$E = 80\,000 \text{ MPa}$$

$$\nu = 0.35$$

$$\alpha_f = 0.$$

$$\alpha_c = 0.$$

$$a_1 = 2.40 \text{ MPa}$$

$$m_1 = 0.$$

$$n_1 = 4.40$$

$$Q_1 = 19900. K$$

$$M_{rrr}^1 = 1.$$

$$M_{\theta\theta\theta\theta}^1 = 1.$$

$$M_{zzzz}^1 = 1.$$

$$M_{r\theta r\theta}^1 = 0.75$$

$$M_{rzrz}^1 = 0.75$$

$$M_{\theta_z \theta_z}^1 = 0.75$$

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 meshes: 2  
1 QUAD4  
1 SEG2

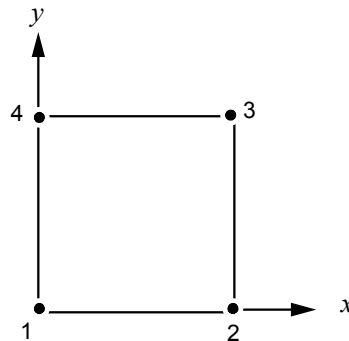
## 3.3 Sizes tested and results

	Identification	Reference
$t=2$	Displacement $DX$ ( $N3$ )	-527.4259
$t=2$	Constraints $SIGYY$ ( $PGI$ )	236.6860
$t=2$	Variable $p$ $VARI$ ( $PGI$ )	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  $t=0s$  and  $t=1s$ , 500 increments enters  $t=1s$  and  $t=2s$ )

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:

$$E = 80\,000 \text{ MPa}$$

$$\nu = 0.35$$

$$n = 4.39$$

$$\frac{1}{K} = 0.003944$$

$$UN\_SUR\_M = 0.$$

### 4.2 Characteristics of the grid

Many nodes: 4

Many meshes: 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 $SIGYY$ ( $PGI$ )	236.6860	1.0%
$t=2$	Variable $p$ $VARI$ ( $PGI$ )	1.4984	1.5%

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Responsable : DE BONNIÈRES Philippe

Date : 30/01/2013 Page : 7/10  
Clé : V7.22.136 Révision :  
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## 5 Modeling C

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### 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 $SIGYY$ ( $PGI$ )	236.6860	1.0%
$t=2$	Variable $p$ $VARI$ ( $PGI$ )	1.4984	1.5%



## 6 Modeling D

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### 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 <i>EPYY</i> ( <i>PGI</i> )	0,105
$t=1.03$	Constraints <i>SIGYY</i> ( <i>PGI</i> )	337.24
$t=1.03$	Variable <i>p</i> <i>VARI</i> ( <i>PGI</i> )	0.10078

## 7 Summary of the results

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