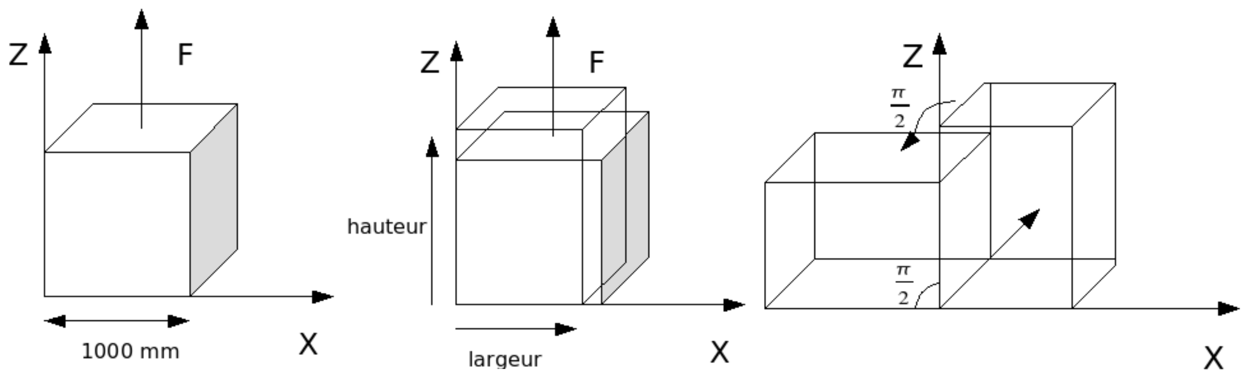
SSND107: Multiple tensions rotations in large deformations, kinematic hardening and mixed

Abstract:

This test models an element subjected to four cycles tension-rotation of rigid body of $45°$, with the elastoplastic constitutive laws with kinematic hardening and mixed in hypoelastic large deformations (GDEF_HYPO_ELAS for the modelization A and GDEF_LOG for the modelization B). One checks on the one hand the invariance of the equivalent stress of von Mises during the phases of rotation, and that the values obtained with the various constitutive laws are identical. This test validates the processing of the kinematic hardening made in the frame of the hypoelastic large deformations.

1 Problem of reference

1.1 Figure1



Geometry: Problem of reference (for a rotation of $90°$)

One considers a cubic matter element on $1000\,mm$ side subjected alternatively to a tensile force then with an overall rotation of $45°$. It undergoes in all 4 cycles tension/rotation.

1.2 Material characteristics

One considers here 6 elastoplastic constitutive laws with kinematic hardening or kinematical/isotropic compound of type von Mises:
`VMIS_CINE_LINE`, `VMIS_ECMI_LINE`, `VMIS_ECMI_TRAC`,
`VMIS_CIN1_CHAB` and `VMIS_CIN2_CHAB VMIS_CIN2_MEMO`.

Table below list parameters used; in order to reinforce the comparison, the parameters used lead to identical constitutive laws in the 5 cases (linear hardening).

Mot_Clé	Parameter	Value
ELAS	E	$200\,000\,MPa$
	NU	$0{,}3$
TENSION	SIGM	$(0.001{,}200);(0.002{,}202)$
ECRO_LINE	D_SIGM_EPSI	$2\,000\,MPa$
	SY	$200\,MPa$
PRAGER	C	$\frac{2}{3}\frac{E*\mathrm{D\_SIGM\_EPSI}}{E-\mathrm{D\_SIGM\_EPSI}}\simeq 1346{,}8\,MPa$
CIN1_CHAB	C_I	$\frac{E*\mathrm{D\_SIGM\_EPSI}}{E-\mathrm{D\_SIGM\_EPSI}}\simeq 2020{,}2\,MPa$
	R_0	$200\,MPa$
	R_I	$200\,MPa$

	G_0	0
CIN2_CHAB	C1_I	$\frac{1}{2}\frac{E*\text{D\_SIGM\_EPSI}}{E-\text{D\_SIGM\_EPSI}}\simeq 1010{,}1\,MPa$
	C2_I	$\frac{1}{2}\frac{E*\text{D\_SIGM\_EPSI}}{E-\text{D\_SIGM\_EPSI}}\simeq 1010{,}1\,MPa$
	R_0	$200\,MPa$
	R_I	$200\,MPa$
	G1_0	0
	G2_0	0

MEMO_ECRO	MU	0
	Q_M	0
	Q_0	0
	ETA	0

1.3 Boundary conditions and loadings

Two types of phase must be distinguished: phases of tension and the phases of rotation. During the phases of tension, one blocks normal displacements of the front and back sides.

Phases of tension:

First phase of Standard

tension	Entity charges	Value
lower Face	FACE_IMPO	$DNOR=0$
Upper face	FACE_IMPO	$DNOR=500\text{mm}$
Centers rotation	DDL_IMPO	$DX=0$
front Face	FACE_IMPO	$DNOR=0$
back Face	FACE_IMPO	$DNOR=0$

following Tensions:

Standard	entity charges	Value
lower Face	LIAISON_OBLIQUE	$DZ=0$
Upper face	LIAISON_OBLIQUE	$DZ=200\text{mm}$
Side $X=0$; $Z=1\text{mm}$	LIAISON_OBLIQUE	$DX=0$
Centers rotation	DDL_IMPO	$DX=0, DZ=0$
front Face	DDL_IMPO	$DY=0$
back Face	DDL_IMPO	$DY=0$

Each phase of tension is made up of 5 identical increments.

Phase of rotation:

Limiting conditions

Standard	Entity charges	Value
Centers rotation	DDL_IMPO	$DX=0, DZ=0$
front Face	DDL_IMPO	$DY=0$
back Face	DDL_IMPO	$DY=0$

the loading of rotation is imposed via a macro named CHAR_ROTA ; one imposes an overall rotation from $45°$ phase, cut out in 5 increments of $9°$.

One obtains at the end of the loading a strain of 2.145.

2 Results of reference

This test does not have result of reference as tel.

One compares the solutions provided by each model between them (they are supposed to be equivalent).

Moreover, one checks the constant character of the equivalent stress of Von Mises during the phases of rotation.

3 Modelization A

3.1 Characteristic of the modelization

This modelization makes it possible to test GDEF_HYPO_ELAS in 3D.

3.2 Characteristics of the mesh

The mesh consists of a linear hexahedral mesh (with 8 nodes).

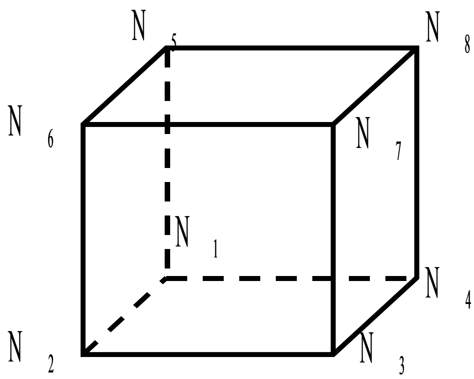


Figure 2: Mesh of the modelization A

3.3 Quantities tested and results

Behavior VMIS_CINE_LINE

Displacement imposed	Quantities tested	Reference MPa	Tolerance %
$500\,mm$	SIEQ_ELGA	1126.4	0,2
$700\,mm$	SIEQ_ELGA	1368.8	0,1
$900\,mm$	SIEQ_ELGA	1557.4	0,1
$1100\,mm$	SIEQ_ELGA	1750.7	0,1

Behavior VMIS_ECMI_LINE

Displacement imposed	Quantities tested	Reference MPa	Tolerance %
$500\,mm$	SIEQ_ELGA	1126.4	0,2
$700\,mm$	SIEQ_ELGA	1368.8	0,1
$900\,mm$	SIEQ_ELGA	1557.4	0,1
$1100\,mm$	SIEQ_ELGA	1750.7	0,1

Behavior VMIS_ECMI_TRAC

Displacement imposed	Quantities tested	Reference MPa	Tolerance %
$500\,mm$	SIEQ_ELGA	1126.4	0,2
$700\,mm$	SIEQ_ELGA	1368.8	0,1
$900\,mm$	SIEQ_ELGA	1557.4	0,1
$1100\,mm$	SIEQ_ELGA	1750.7	0,1

Behavior VMIS_CIN1_CHAB

Displacement imposed	Quantities tested	Reference MPa	Tolerance %
$500\,mm$	SIEQ_ELGA	1126.4	0,2
$700\,mm$	SIEQ_ELGA	1368.8	0,1
$900\,mm$	SIEQ_ELGA	1557.4	0,1
$1100\,mm$	SIEQ_ELGA	1750.7	0,1

Behavior VMIS_CIN2_CHAB

Displacement imposed	Quantities tested	Reference MPa	Tolerance %
$500\,mm$	SIEQ_ELGA	1126.4	0,2
$700\,mm$	SIEQ_ELGA	1368.8	0,1
$900\,mm$	SIEQ_ELGA	1557.4	0,1
$1100\,mm$	SIEQ_ELGA	1750.7	0,1

Behavior VMIS_CIN2_MEMO

Displacement imposed	Quantities tested	Reference MPa	Tolerance %
$500\,mm$	SIEQ_ELGA	1126.4	0,2
$700\,mm$	SIEQ_ELGA	1368.8	0,1
$900\,mm$	SIEQ_ELGA	1557.4	0,1
$1100\,mm$	SIEQ_ELGA	1750.7	0,1

4 Modelization B

4.1 Characteristic of the modelization

This modelization makes it possible to test GDEF_LOG in 3D.

4.2 Characteristics of the mesh

The mesh consists of a linear hexahedral mesh (with 8 nodes).

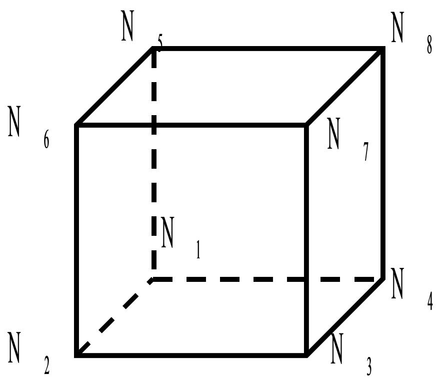


Figure 2: Mesh of the modelization B

4.3 Quantities tested and results

Behavior VMIS_CINE_LINE, GDEF_LOG

Displacement imposed	Quantities tested	Reference MPa	Tolerance %
$500\,mm$	SIEQ_ELGA	1126.4	0,2
$700\,mm$	SIEQ_ELGA	1368.8	0,1
$900\,mm$	SIEQ_ELGA	1557.4	0,1
$1100\,mm$	SIEQ_ELGA	1750.7	0,1

Behavior VMIS_ECMI_LINE

Displacement imposed	Quantities tested	Reference MPa	Tolerance %
$500\,mm$	SIEQ_ELGA	1126.4	0,2
$700\,mm$	SIEQ_ELGA	1368.8	0,1
$900\,mm$	SIEQ_ELGA	1557.4	0,1
$1100\,mm$	SIEQ_ELGA	1750.7	0,1

Behavior VMIS_ECMI_TRAC

Displacement imposed	Quantities tested	Reference MPa	Tolerance %
$500\,mm$	SIEQ_ELGA	1126.4	0,2
$700\,mm$	SIEQ_ELGA	1368.8	0,1
$900\,mm$	SIEQ_ELGA	1557.4	0,1
$1100\,mm$	SIEQ_ELGA	1750.7	0,1

Behavior `VMIS_CIN1_CHAB`

Displacement imposed	Quantities tested	Reference MPa	Tolerance %
$500\,mm$	`SIEQ_ELGA`	1126.4	0,2
$700\,mm$	`SIEQ_ELGA`	1368.8	0,1
$900\,mm$	`SIEQ_ELGA`	1557.4	0,1
$1100\,mm$	`SIEQ_ELGA`	1750.7	0,1

Behavior `VMIS_CIN2_CHAB`

Displacement imposed	Quantities tested	Reference MPa	Tolerance %
$500\,mm$	`SIEQ_ELGA`	1126.4	0,2
$700\,mm$	`SIEQ_ELGA`	1368.8	0,1
$900\,mm$	`SIEQ_ELGA`	1557.4	0,1
$1100\,mm$	`SIEQ_ELGA`	1750.7	0,1

Behavior `VMIS_CIN2_MEMO`

Displacement imposed	Quantities tested	Reference MPa	Tolerance %
$500\,mm$	`SIEQ_ELGA`	1126.4	0,2
$700\,mm$	`SIEQ_ELGA`	1368.8	0,1
$900\,mm$	`SIEQ_ELGA`	1557.4	0,1
$1100\,mm$	`SIEQ_ELGA`	1750.7	0,1

5 Summary of the results

the got results are satisfactory. It is noted that all the constitutive laws lead well to identical results and that the rotation of rigid body does not generate any additional stress. The models of large deformations tested are thus quite objective.

One notes a light difference between GDEF_HYPO_ELAS and GDEF_LOG, due to the choice of strain measurement (cf figure 3).

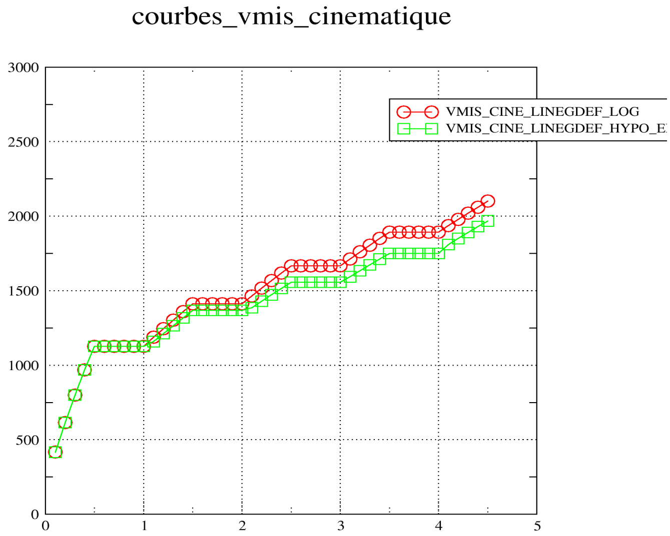


Figure 3: Curves forced/urgent for the 2 modelizations (identical results for all the behaviors)