

## SSND106: Multiple tractions rotations in great deformations, isotropic work hardening

---

### Summary:

This test models a material point subjected to four cycles traction-rotation of rigid body of  $45^\circ$ , with an elastoplastic law of behavior of Von Mises with isotropic work hardening in great deformations (hypoelastic formulation `GDEF_HYPO_ELAS`, formulation with deformation logarithmic curve `GDEF_LOG`). One checks on the one hand the invariance of the equivalent constraint of Von Mises during the phases of rotation, and on the other hand his values during tractions while comparing with the modeling of `SIMO_MIEHE`.

Modelings *A* and *B* deal with the problem in plane deformations, that is to say in  $3D$  (*A*), that is to say in `D_PLAN` (*B*).

Modelings *C* and *D* deal with the problem in plane constraints, that is to say in  $3D$  (*C*), that is to say in `C_PLAN` (*D*).

## 1 Problem of reference

### 1.1 Geometry

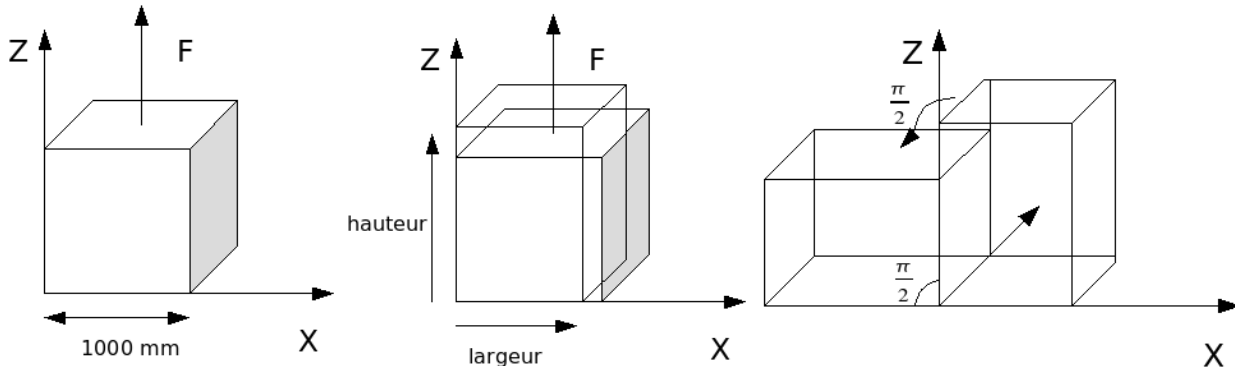


Figure1: Problem of reference (for a rotation of  $90^\circ$ )

One considers a cubic matter element of  $1000\text{ mm}$  on side subjected alternatively to a force of traction then to an overall rotation of  $45^\circ$ . It undergoes in all 4 cycles traction/rotation.

### 1.2 Data material

One considers here the elastoplastic law of behaviour to isotropic work hardening of type von Mises: VMIS\_ISOT\_LINE. Table below list parameters used; in order to reinforce the comparison, the parameters used lead to identical laws of behavior in the 2 cases (linear isotropic work hardening).

Young modulus:	200 000 MPa
Poisson's ratio	0,3
Elastic limit	200 MPa
Linear module of work hardening	2 000 MPa

### 1.3 Boundary conditions and loadings

In modeling  $A$ , in 3D one blocks normal displacements of the front and back faces, in order to compare the results with modeling  $B$  2D (D\_PLAN).

In modeling  $C$ , also in 3D one leaves free displacements of the front and back faces, in order to compare the results with modeling  $D$  2D (C\_PLAN).

Two types of phases must be distinguished: phases of traction and phases of rotation.  
First phase of traction

Entity	Type charges	Value
Lower face	FACE_IMPO	DNOR=0
Higher face	FACE_IMPO	DNOR=500mm
Axis rotation	DDL_IMPO	DX=0

Front face ( 3D )	FACE_IMPO	DNOR=0
Face postpones ( 3D )	FACE_IMPO	DNOR=0

Following tractions:

Entity	Type charges	Value
Lower face	LIAISON_OBLIQUE	DZ=0
Higher face	LIAISON_OBLIQUE	DZ=200mm
Side $X=0$ ; $Z=1$ mm	LIAISON_OBLIQUE	DX=0
Axis rotation	DDL_IMPO	DX=0, DZ=0
Front face ( 3D )	DDL_IMPO	DY=0
Face postpones ( 3D )	DDL_IMPO	DY=0

Phase of rotation:

Boundary conditions

Entity	Type charges	Value
Axis rotation	DDL_IMPO	DX=0, DZ=0
Front face ( 3D )	DDL_IMPO	DY=0
Face postpones ( 3D )	DDL_IMPO	DY=0 or free

The loading of rotation is imposed via macro named CHAR\_ROTA ; one imposes an overall rotation of  $45^\circ$  by phase, cut out in 5 increments of  $9^\circ$ .

## 2 Results of reference

The results of reference are got by carrying out same calculation with the model of great deformations of Simo-Miehe (DEFORMATION = 'SIMO-MIEHE'), validated in addition.

Behavior VMIS\_ISOT\_LINE with SIMO\_MIEHE, in plane deformation:

Imposed displacement	Size tested	Reference (MPa)
500 mm	SIEQ_ELGA	1125
700 mm	SIEQ_ELGA	1411
900 mm	SIEQ_ELGA	1664
1100 mm	SIEQ_ELGA	1891,7

One compares the values of the equivalent constraints of von Mises at the end of the phases of traction and one checks their invariance during the phases of rotation.

Behavior VMIS\_ISOT\_LINE with SIMO\_MIEHE in plane constraint

Imposed displacement	Size tested	Reference (MPa)
500 mm	SIEQ_ELGA	1019,57
500 mm after rotation	SIEQ_ELGA	1019,57
700 mm	SIEQ_ELGA	1271

One checks finally the quality of the tangent matrix by comparison with a tangent matrix obtained by disturbance. One obtains with `SIMO_MIEHE`, a quasi worthless difference (standard of the difference: of the order of  $1.E-20$  ). One will thus check the difference obtained on the tangent matrix for the formalisms in great deformations tested here.

## 3 Modeling A

### 3.1 Characteristic of modeling

Modeling is 3D.

### 3.2 Characteristics of the grid

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

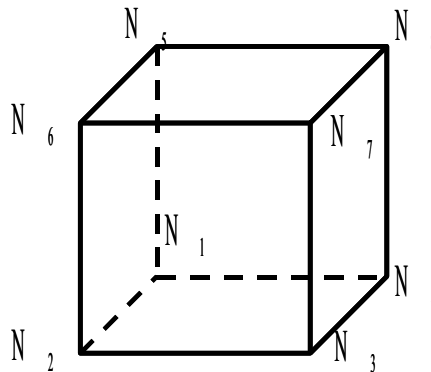


Figure 2: Grid of modeling A

### 3.3 Sizes tested and results

Behavior VMIS\_ISOT\_LINE with GDEF\_HYPO\_ELAS

Imposed displacement	Size tested	Reference (MPa)	Tolerance (%)
500 mm	SIEQ_ELGA	1125	0.2
700 mm	SIEQ_ELGA	1411	0.2
900 mm	SIEQ_ELGA	1664	0.2
1100 mm	SIEQ_ELGA	1891,7	0.2

Behavior VMIS\_ISOT\_LINE with GDEF\_LOG

Imposed displacement	Size tested	Reference (MPa)	Tolerance (%)
500 mm	SIEQ_ELGA	1125	0.2
700 mm	SIEQ_ELGA	1411	0.2
900 mm	SIEQ_ELGA	1664	0.2
1100 mm	SIEQ_ELGA	1891,7	0.2

## 4 Modeling B

### 4.1 Characteristic of modeling

Modeling used is two-dimensional. The elements are used D\_PLAN

### 4.2 Characteristics of the grid

The grid consists of a linear quadrangular mesh (with 4 nodes).

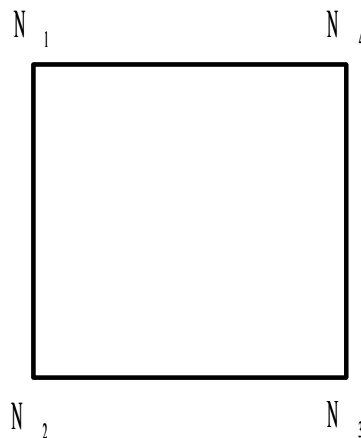


Figure 3: Grid of modeling B

### 4.3 Sizes tested and results

Behavior VMIS\_ISOT\_LINE with GDEF\_HYPO\_ELAS

Imposed displacement	Size tested	Reference (MPa)	Tolerance (%)
500mm	SIEQ_ELGA	1125	0.2
700mm	SIEQ_ELGA	1411	0.2
900mm	SIEQ_ELGA	1664	0.2
1100mm	SIEQ_ELGA	1891,7	0.2

Behavior VMIS\_ISOT\_LINE with GDEF\_LOG

Imposed displacement	Size tested	Reference (MPa)	Tolerance (%)
500mm	SIEQ_ELGA	1125	0.2
700mm	SIEQ_ELGA	1411	0.2
900mm	SIEQ_ELGA	1664	0.2
1100mm	SIEQ_ELGA	1891,7	0.2

## 5 Modeling C

### 5.1 Characteristic of modeling

Modeling is 3D, and a state of plane stress simulates. One considers here only one traction, a rotation and a new traction.

### 5.2 Characteristics of the grid

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

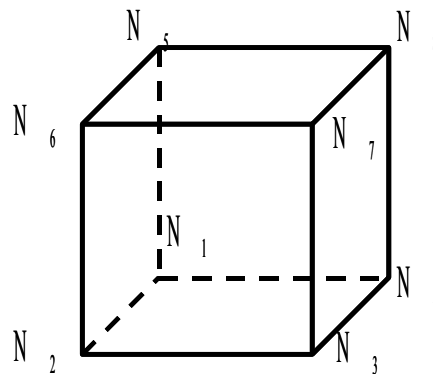


Figure 4: Grid identical to that of modeling A

### 5.3 Sizes tested and results

Behavior VMIS\_ISOT\_LINE with GDEF\_LOG

Imposed displacement	Size tested	Reference (MPa)	Tolerance (%)
500 mm	SIEQ_ELGA	1019,57	2
500 mm after rotation	SIEQ_ELGA	1019,57	2
700 mm	SIEQ_ELGA	1271	2

Behavior VMIS\_ISOT\_LINE with GDEF\_HYPO\_ELAS

Imposed displacement	Size tested	Reference (MPa)	Tolerance (%)
500 mm	SIEQ_ELGA	1019,57	2
500 mm after rotation	SIEQ_ELGA	1019,57	2
700 mm	SIEQ_ELGA	1271	2

## 6 Modeling D

### 6.1 Characteristic of modeling

Modeling used is two-dimensional in plane constraint ( $C\_PLAN$ ). The goal of this modeling is to validate the algorithm of great deformations  $GDEF\_LOG$  in  $C\_PLAN$ . One thus compares the results with those obtained by  $GDEF\_LOG$  in modeling  $C$ , which treats in 3D a problem are equivalent.

### 6.2 Characteristics of the grid

The grid consists of a linear quadrangular mesh (with 4 nodes).

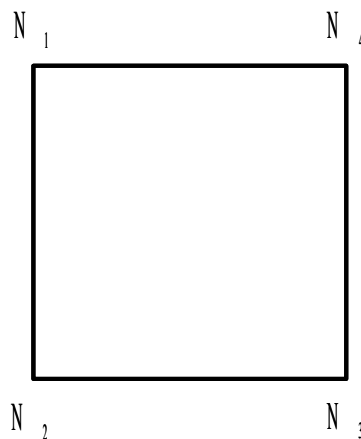


Figure 5: Grid identical to that of modeling  $B$

### 6.3 Sizes tested and results

Behavior  $VMIS\_ISOT\_LINE$  with  $GDEF\_LOG$

Imposed displacement	Size tested	Reference ( $MPa$ )	Tolerance (%)
500 mm	SIEQ_ELGA	1006,9	0.1
500 mm after rotation	SIEQ_ELGA	1006,9	0.1
700 mm	SIEQ_ELGA	1256,1	0.1



## 7 Summary of the results

---

Got results are satisfactory, as well in 3D that in 2D . One notes a maximum change lower than 0,2% enter SIMO\_MIEHE (taken as reference) and formalisms GDEF\_HYPO\_ELAS and GDEF\_LOG.

This test also validates the good performance of GDEF\_LOG in plane constraints.

Moreover, for all modelings, the equivalent constraint remains constant during the phases of rotations.