MFRON01 – Test of the interface *Code_Aster*- MFront for laws élasto-visco-plastics

Summary:

This test validates laws of elastoplastic behavior and viscoplastic standard (used in particular for metals: plasticity of Von Mises, Chaboche, Norton,…) defined using *MFront* by comparison with similar behaviors of *Code_Aster* .

Each modeling validates a law of behavior, generally by comparison with the results of the equivalent law of *Code_Aster*.

1 Modeling A

1.1 Characteristics of modeling

- Behavior tested: Chaboche.mfront. Elastoplastic law of Chaboche with two variable kinematics, comparable to VMIS_CIN2_CHAB [cf R5.03.04].
- Modeling and data similar to those of test SSNV101A.

1.2 Sizes tested and results

The reference solution is that obtained by behavior VMIS_CIN2_CHAB

Identification (t=1.435)	Reference	Tolerance
ε_{xx}	0.0960649	0,1%
ε_{xy}	0.1438997	0,1%
σ_{xx}	143.50	0,1%
p	0.190153	0,1%

2 Modeling B

2.1 Characteristics of modeling

- Behavior tested: ViscoChaboche.mfront. Law élasto-visco-plastic of Chaboche with two variable kinematics, comparable to VISC_CIN2_CHAB [cf R5.03.04].
- Modeling and data similar to those of test HSNV125A.

2.2 Sizes tested and results

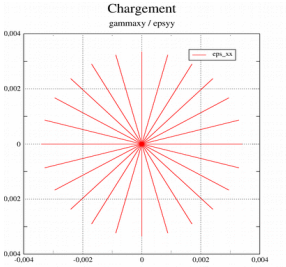
One compares the solution obtained with the Mfront behavior and that obtained with behavior VISC_CIN1_CHAB

Constraint (MPa)	Moment (S)	Reference (difference)	Absolute tolerance
SIXX	Maximum change	0	0.0002
SIXY	Maximum change	0	0.0002

3 Modeling C

3.1 Characteristics of modeling

- Behavior tested: ViscoMemoNrad.mfront. Law elastoplastic of Chaboche with effects of memory and nonradiality, comparable to VISC_MEMO_NRAD [cf R5.03.04].
- Test of traction-torsion, “star” loading. Modeling and data similar to those of test SSND115A.



3.2 Sizes tested and results

The reference solution is that obtained by behavior VISC_MEMO_NRAD

Extreme values	Reference	Tolerance
$max(\sigma_{xx})$	413.85873	0,1%
$min(\sigma_{xx})$	-415.03392	0,1%
$max(\sigma_{xy})$	244.14796	0,1%
$min(\sigma_{xy})$	-243.38215	0,1%

4 Modeling D

4.1 Characteristics of modeling

- Behavior tested: Chaboche.mfront. Elastoplastic law of Chaboche with two variable kinematics, comparable to VMIS_CIN2_CHAB, in plane constraints
- Modeling similar to that of test SSNV101B.

4.2 Sizes tested and results

The reference solution is that obtained by behavior VMIS_CIN2_CHAB

Identification (t=1.435)	Reference	Tolerance
ε_{xx}	0.0960649	0,1%
ε_{xy}	0.1438997	0,1%
σ_{xx}	143.50	0,1%
p	0.190153	0,1%

5 Modeling E

5.1 Characteristics of modeling

- Behaviors tested: Norton.mfront Norton_Jacnum.mfront ImplicitNorton.mfront Norton_RK54.mfront. They are various integrations of the law of Norton viscoplastic, which is a typical case of the law of Lemaître (cf R5.03.08].
- Modeling and data similar to that of test SSNP02 (not material, modeling 3D)

5.2 Sizes tested and results

The reference solution is that obtained by behavior LEMAITRE

Identification (t=30)		Reference	Tolerance
Norton	ε_{xx}	0.0155665	0,1%
Norton_Jacnum	ε_{xx}	0.0155665	0,1%
ImplicitNorton	ε_{xx}	0.0155665	0,1%
Norton_RK54	ε_{xx}	0.0155665	0,1%
Norton	ε_{xy}	0.0164792	0,1%

6 Modeling F

6.1 Characteristics of modeling

- Behavior tested: ImplicitNorton.mfront. Law of Norton viscoplastic, which are a typical case of the law of Lemaître (cf R5.03.08]), tested here in plane constraints and axisymetry.
- Modeling and data similar to that of test SSNA107A.

6.2 Sizes tested and results

The reference solution is analytical (cf [v6,01,107]).

Size	Not	Moments	Case	Reference	Tolerance %
DX	B	4	AXIS	-0.2109	0.1%
$SIYY$	B	4	AXIS	0.2616	0.2%
$SIYY$	B	4	CPLAN	0.2616	0.2%

7 Modeling G

7.1 Characteristics of modeling

- Behavior tested: PlasticityTH.mfront (which imports Plasticity_Sy.mfront). Elastoplastic law of Von Mises, comparable to VMIS_ISOT_LINE, with effect of the temperature.
- Modeling similar to that of test HSNV100J. The elastic limit varies according to the temperature in the following way: $\sigma_y = 400.0 - 4.0\,T$;
- the other properties material are constant: $E = 200\,GPa$, $\nu = 0{,}3$, $E_T = 50\,GPa$

7.2 Sizes tested and results

The reference solution is analytical (cf [V7.22.100]):

Variables	Moments (s)	Reference
ε_{xx}	$t = 66.666$	8.6666 10⁻⁴
	$t = 80$	1.1000 10⁻³
	$t = 90$	1.2750 10⁻³
p	$t = 66.666$	0
	$t = 80$	3.0000 10⁻⁴
	$t = 90$	5.2500 10⁻⁴
σ_{yy} (MPa)	$t = 66.666$	– 133,333
	$t = 80$	– 100.
	$t = 90$	– 75,000

8 Modeling H

8.1 Characteristics of modeling

- Behavior tested: ImplicitSimoMieheElastoPlasticity.mfront and Plasticity.mfront.

  Elastoplastic law of using Von Mises in great deformations is the formulation of Simo and Miehe, comparable to VMIS_ISOT_LINE, with DEFORMATION=' SIMO_MIEHE' (cf [R5.03.21]), that is to say DEFORMATION=' GDEF_LOG' (cf [R5.03.24]).

- Modeling and data similar to those of test SSNP159A.

8.2 Sizes tested and results

The reference solution is that obtained by behavior VMIS_ISOT_LINE and SIMO_MIEHE.

Identification	Reference Aster		Tolerance
	SIMO_MIEHE	GDEF_LOG	Mfront/Aster
$t=2$ Displacement DX ($N8$)	290	290	0.1 %
$t=2$ Constraints $SIGXX$ ($PG1$)	1500.55	1494.80	0.1 %
$t=2$ Variable p $VARI$ ($PG1$)	0.25	0.2475	0.1 %

9 Modeling I

9.1 Characteristics of modeling

- Behavior tested: SaintVenantKirchhoffElasticity. Elastic law in great deformations.
- Modeling is equivalent to that of a file mtest (not material) of Mfront:
  - $E=215 GPa$, $\nu=0,3$,
  - gradient of transformation imposed such as: $F_{11}=1.2t \quad F_{22}=F_{33}=1$

9.2 Sizes tested and results

The reference solution is analytical:

$$\sigma_{xx}=F_{xx}(\lambda+2*\mu)(F_{xx}^2-1)/2 \qquad \sigma_{yy}=\sigma_{zz}=\frac{\lambda(F_{xx}^2-1)}{2F_{xx}}$$

Identification (t=1)	Reference	Tolerance
$\sigma_{xx}(Pa)$	76407,69e6	0
$\sigma_{yy}(Pa)$	22740,38e6	0
$\sigma_{zz}(Pa)$	22740,38e6	0

10 Modeling J

10.1 Characteristics of modeling

- Behavior tested: Chaboche. Modeling DKT.
- Modeling is equivalent to that of the test ssnl501b

10.2 Sizes tested and results

The reference solution is analytical.

Identification	Moments	Type of reference	Reference	Tolerance (%)
ETA_PILOTAGE	5	'ANALYTICAL'	1.0	15.
ETA_PILOTAGE	15	'ANALYTICAL'	1.0	15.

11 Summary of the results

The results are satisfactory and validate the interface enters *Code_Aster* and MFRONT in small and great deformations, for behaviors élasto-visco-plastics of metals.