SSNV194 – Tension on an aggregate with 10 grains

Summarized:

One presents here a test of tension on an aggregate to 10 grains with the model Monocrystal in *Code_Aster*. The directional senses are defined in Eulerian angles.

The modelization A corresponds to a computation of complete aggregate, with definition of the directional senses for each grain with a grid.

The modelization B corresponds to a computation homogenized, on only one finite element.

The modelization C corresponds to a computation homogenized in a material point.

The modelization D corresponds to a homogenized computation, on a material point, for a polycrystal made up of 100 grains `DD_CC`.

The modelization E is similar to the modelization A, put except for one uses meshes TETRA10 and a modelization `3D_SI`.

The modelization F corresponds to a homogenized computation, on a material point, for a polycrystal made up of 100 grains `DD_CC_IRRA`.

The modelization G corresponds to a homogenized computation, on a material point, for a polycrystal made up of 100 grains `DD_CFC_IRRA`.

1 Problem of reference

1.1 Geometry

the geometry is that of a polycrystal, represented:

- Maybe by a mesh on side 1, generated by a procedure python.
- Maybe by homogenization on a material point.

1.2 Properties of the materials

Modelizations A, B, C, E

Young's modulus: $E=145200\ MPa$, Poisson's ratio: $\nu=0.3$

MONO_VISC1: $N=10 \quad K=40 \quad C=1$

MONO_ISOT1 : $R_0=75.5 \quad b=19.34 \quad Q=9.77 \quad h_1=h_2=h_3=h_4=1$

MONO_CINE1: $D=36.68$

The directional senses of sliding systems of each grain, represented by a mesh group GROUP_MA, are given in Eulerian angles.

Modelizations D and F: MONO_DD_CC
$\mathrm{TEMP}=50\,K$, Poisson's ratio $\nu=0.35$ Modulus Young: $E=(236-0{,}0459\,T)$ GPa $\mathrm{D\_LAT}=1000\,\mathrm{mm}$ $\mathrm{K\_BOLTZ}=8.62\ 10^{-5}$ $DELTA1=1.0$ $\mathrm{GAMMA0}=10^{-6}s^{-1}$ $\mathrm{TAU\_0}=363\,\mathrm{MPa}$ $\mathrm{TAU\_F}=0$ $\mathrm{RHO\_MOB}=10^{5}\ \mathrm{mm}^{-2}$ $\mathrm{K\_F}=75$ $\mathrm{K\_SELF}=100$ $\mathrm{B}=2.48\ 10^{-7}\,\mathrm{mm}$ $\mathrm{N}=50$ $\mathrm{DELTAG0}=0.84$ $\mathrm{BETA}=0.2$ $\mathrm{D}=10^{-5}\,\mathrm{mm}$ $\mathrm{GH}=10^{11}$, $\mathrm{Y\_AT}=2\,10^{-6}\,\mathrm{mm}$ the local variables representing the density of dislocations are initialized with $\rho_0=6.\,10^{5}\,mm^{-2}$, the matrix of interaction is built in both cases starting from the following values $\mathrm{H1}=0.1$, $\mathrm{H2}=0.7$, $\mathrm{H3=H4=H5=H6}=0.1$

Modelization G: MONO_DD_CFC_IRRA

$A=0.13 \quad B=0.005 \quad \alpha=0.35 \quad \beta=2.54 10^{-7}(2.54\ Angström)$

$Y=2.5\ \ 10^{-7}mm(2.5\,Angstrom) \quad \tau_f=20. \quad n=5. \quad \dot{\gamma}_0=10^{-3} \quad \rho_{ref}=10^{6}\,mm^{-2}$

$\alpha^{loops}=1 \quad \phi^{loops}=0.001 \quad \alpha^{voids}=1 \quad \rho^{voids}=1.e3$

$\rho_{sat}=4\rho_0 b^2 \quad \phi_{sat}=0.04 \quad \xi_{irra}=10^7 \quad \zeta_{irra}=10^7$ with $\rho_0=10^5\,mm^{-2}$

the matrix of interaction is only made up of 1: $H1=H2=H3=H4=H5=1.0$,

The local variables representing the density of dislocations are initialized with $\rho_0\times b^2$

Those which are related to the irradiation have as initial values: $\rho_s^{loops}=2\rho_0 b^2 \quad \phi_s^{voids}=0.001$

1.3 Boundary conditions and loadings

	Modelizations A, B, C, F	Modelization D, E
GROUP_NO: BACK	$DX=0$	$DX=0$
GROUP_NO: LOW	$DZ=0$	$DZ=0$
GROUP_NO: GAUCHE	$DY=0$	$DY=0$
GROUP_NO: HIGH	$DZ=\alpha t \quad \alpha=1$ $0<t<0{,}005$	$DZ=\alpha t \quad \alpha=3\,10^{-4}$, $\varepsilon_{max}=0.2$

2 Reference solution

It is a case test of NON-regression with regard to the modelizations A, E, F, G.
the results of the modelizations B and C are compared with those of modelization A.

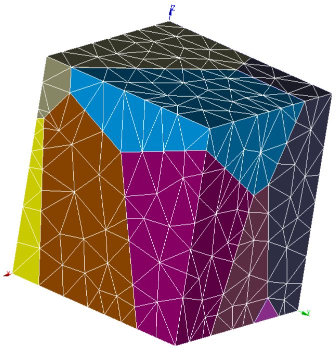
3 Modélisation A

3.1 Characteristic of the modelization

the structure contains 10 grains. To each grain corresponds 3 Eulerian angles which lay down the directions of sliding systems. Sliding system families of bcc24 *type*.

3.2 Characteristics of the mesh

Many nodes: 552.
Modelization 3D : 2269 tetrahedral volume elements: TETRA4.



3.3 Quantities tested and results

the First computation (boundary conditions AFFE_CHAR_MECA)

Standard	Identification of reference	Value of reference	Tolerance
SIEF_ELGA σ_{xx} does not net $M1$ 1	"NON_REGRESSION"	-25,172 Mpa	0,01%
EPSI_ELGA ε_{xx} does not net $M1$ 1	"NON_REGRESSION"	-1,49584E-03	0,01%
EPSI_ELGA ε_{yy} does not net $M1$ 1	"NON_REGRESSION"	-2,70269E-03	0,01%
EPSP_ELGA ε_{yy} does not net $M1$ 1	"NON_REGRESSION"	-2,587725E-03	0,01%
VARI_ELGA $V79$ maximum	"NON_REGRESSION"	488,168492	1,0E-4%
VARI_ELGA $V80$ maximum	"NON_REGRESSION"	8,015907E-03	the 1,0E-4%

Second computation (boundary conditions AFFE_CHAR_CINE)

Standard	Identification of reference	Value of reference	Tolerance
SIEF_ELGA σ_{xx} does not net $M1$ 1	"AUTRE_ASTER"	-25,172 Mpa	0,01%
EPSI_ELGA ε_{xx} does not net $M1$ 1	"AUTRE_ASTER"	-1,49584E-03	0,01%
EPSI_ELGA ε_{yy} does not net $M1$ 1	"AUTRE_ASTER"	-2,70269E-03	0,01%
EPSP_ELGA ε_{yy} does not net $M1$ 1	"AUTRE_ASTER"	-2,587725E-03	0,01%
VARI_ELGA $V79$ maximum	"AUTRE_ASTER"	488,168492	1,0E-4%
VARI_ELGA $V80$ maximum	"AUTRE_ASTER"	8,015907E-03	1,0E-4%

4 Modelization B

4.1 Characteristic of the modelization

homogenized Material including 10 bainitic phases, with sliding system families of bcc24 *type*. With each phase, one in the same way associates 3 Eulerian angles which lay down the directions of sliding systems, that for modelization A.

4.2 Caractéristiques of the mesh

Many nodes: 8
Number of meshes and types: 1 HEXA8

4.3 Quantities tested and Standard

Identification	results of reference	Value of reference	average
Tolerance σ_{zz} SIEF_ELGA	"AUTRE_ASTER"	279,777 Mpa	9,0%
EPSP_ELGA ε_{zz} average	"AUTRE_ASTER"	3,07316E-03	6,0%

5 Modelization C

5.1 Characteristic of the modelization

homogenized Material including 10 grains, with sliding system families of bcc24 *type*. A each phase, one in the same way associates 3 Eulerian angles which lay down the directions of sliding systems, that for modelization A.
Two computations successive are carried out: one with a format of array result in columns, the other with a format in lines. In both cases, an automatic recutting of time step is carried out by controlling the increase in local variable $V_3=\varepsilon_{zz}^{vp}<2.10^{-5}$.

5.2 Characteristics of the mesh

No mesh (SIMU_POINT_MAT)

5.3 Quantities tested and Standard

Identification	results of reference	Value of reference	Tolerance
SIEF_ELGA σ_{zz}	"AUTRE_ASTER"	279,777 Mpa	9,0%
VARI_ELGA $V3$	"AUTRE_ASTER"	3,07316E-03	6,0%
SIEF_ELGA σ_{zz}	"NON_REGRESSION"	301,135 Mpa	0,1%
VARI_ELGA $V3$	"NON_REGRESSION"	2,926067E-03	0,1%

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7 Modelization D

7.1 Characteristic of the modelization

homogenized Material including 100 grains, with sliding system families of cubic type (MONO_DD_CC. Simulation on material point.

7.2 Characteristics of the mesh

Without Quantities

7.3 object tested and results

Identification	inst	Value of reference	Tolerance
SIEF_ELGA layer σ_{zz}	tmax	825,2	2.00%
EPSP_ELGA layer $EPZZ$	tmax	0.1	0.10%

8 Modelization E

8.1 Characteristic of the modelization

Aggregate of 10 grains, identical to the modelization A, the finite elements.

8.2 Characteristics of the mesh

Many nodes: 3712
Modelization 3D_SI: 2269 tetrahedral volume elements: TETRA10.

8.3 Quantities tested and results

the First computation (boundary conditions AFFE_CHAR_MECA)

Standard	Identification of reference	Value of reference	Tolerance
SIEF_ELGA σ_{xx} does not net $M1$ 1	"NON_REGRESSION"	-43.488 Mpa	0,01%
EPSI_ELGA ε_{xx} does not net $M1$ 1	"NON_REGRESSION"	-1.22889E-03	0,01%
EPSI_ELGA ε_{yy} does not net $M1$ 1	"NON_REGRESSION"	-3.15043E-03	0,01%
EPSP_ELGA ε_{yy} does not net $M1$ 1	"NON_REGRESSION"	-2.91648E-03	0,01%
VARI_ELGA $V79$ maximum	"NON_REGRESSION"	502.94757	1,0E-4%
VARI_ELGA $V80$ maximum	"NON_REGRESSION"	0.121881	1,0E-4%

9 Modelization F

9.1 Characteristic of the modelization

homogenized Material including 100 grains, with sliding system families of cubic type (MONO_DD_CC_IRRA). Simulation on material point.

9.2 Characteristics of the mesh

Without Quantities

9.3 object tested and results

Identification	inst	Value of reference
SIEF_ELGA average σ_{zz}	layer	856.587
tmax EPSP_ELGA $EPZZ$	tmax	0.15

10 Modelization G

10.1 Characteristic of the modelization

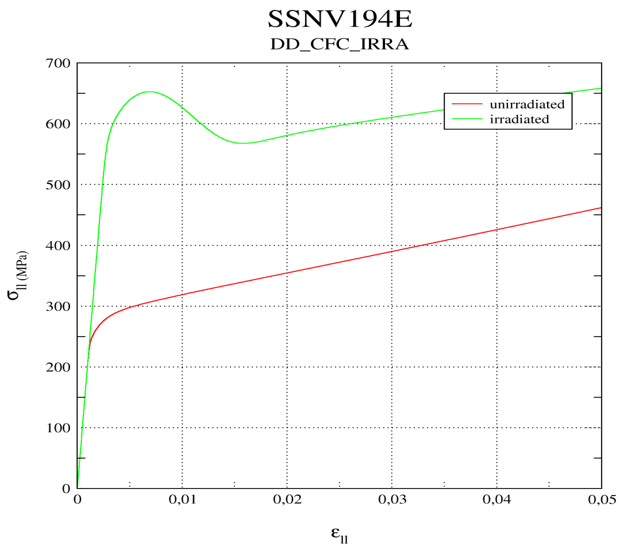
homogenized Material including 100 grains, with sliding system families of cubic type (MONO_DD_CFC_IRRA) . Simulation on material point.

10.2 Characteristics of the mesh

Without Quantities

10.3 object tested and results

Identification	inst	Value of reference
SIEF_ELGA layer σ_{zz}	tmax	658.5459
SIEF_ELGA layer σ_{zz} not irradiated	tmax	461.9796



the validation of the results is qualitative: the influence of the irradiation is well taken into account and the shape of the curve is correct, according to the bibliography.

11 Summary of the results

This test makes it possible to validate by intercomparison a modelization of an aggregate, either with a grid, or homogenized at the level of a hexahedron or that of a material point.