SSNV183 - Creep test with the model VENDOCHAB

Summary:

The model VENDOCHAB, a formulation suggested by Chaboche begins again. It is about a coupled formulation which cover a élasto-viscoplastic law with multiplicative isotropic work hardening and isotropic kinetics of damage. This law was initially developed to predict the lifetime and the cracking of the paddles of the turbojets and more generally to envisage the time of ruin of the requested structures at high temperatures.

This test of nonlinear quasi-static mechanics makes it possible to validate the model VENDOCHAB in $3D$ in the case of a test-tube subjected to an isothermal uniaxial creep test. The stress and strain states are homogeneous in the test-tube. This test validates the explicit integration of this model. The equations of this coupled formulation are described in the booklet of reference [R5.03.15].

The modeling of the test-tube is carried out with an element $3D$ with 8 nodes (HEXA8).

1 Problem of reference

1.1 Geometry

The geometry is selected voluntarily simple, to translate a homogeneous stress and strain state, as it is the case in uniaxial creep. It is here about an element of volume represented by a cube on side $3\,mm$. Modeling is voluminal and creep is done with imposed constraint.

1.2 Properties of material

The characteristics are the following ones:

Keyword ELAS :

- $YOUNG=150000.0\,MPa$
- $NU=0.30$

Keyword VENDOCHAB :

- $S_{VP}=0.$
- $SEDVP1=0.$
- $SEDVP2=0.$
- $N_{VP}=12.$
- $M_{VP}=9.$
- $K_{VP}=2110.$
- $A_D=3191.$
- $R_D=6.3$
- $K_D=14$

1.3 Boundary conditions and loadings

$DZ=0$ on the lower side ($Z=0$)
$DY=0$ on the left side ($Y=0$)
$DX=0$ on the side postpones ($X=0$)

Pressure of $200\,MPa$ imposed on the upper surface, such as:
$P=0$ with $t=0\mathrm{s}$
$P=200\,MPa$ with $t=0.1\mathrm{s}$
$P=200\,MPa$ until $t=2.5\,10^6\,s$

This corresponds to a uniaxial creep test under a constant loading of $200\,MPa$.

1.4 Initial conditions

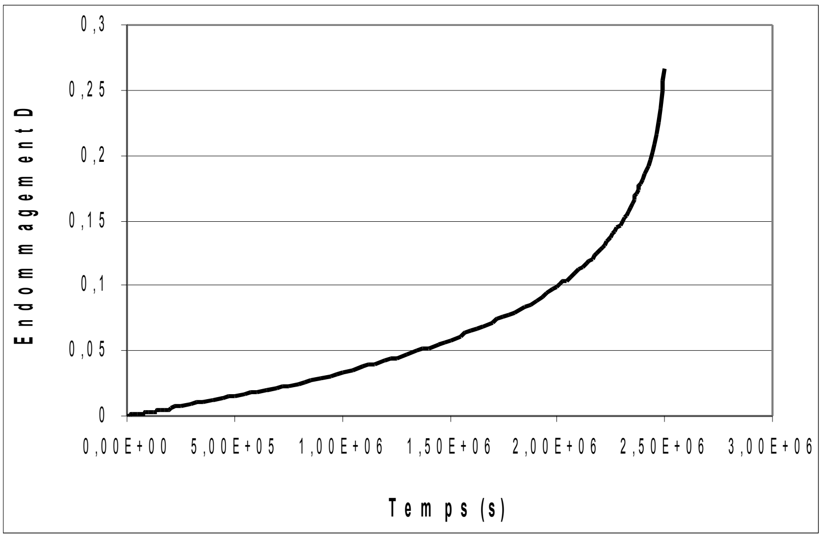
Worthless constraints and deformations.

2 Reference solution

2.1 Method of calculating

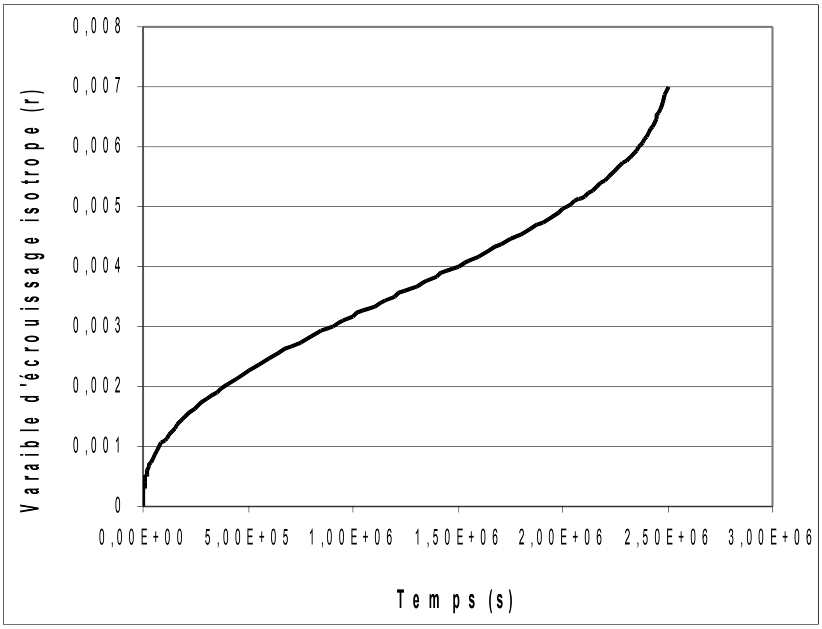
Analytical solution for the variable of damage D :

$$D(t)=1-\left(1-(1+k)\left(\frac{\sigma_0}{A}\right)^R t\right)^{\frac{1}{1+k}}$$



Analytical solution for the variable of isotropic work hardening viscoplastic, r, in the case of a threshold σ_Y no one:

$$r(t)=\left[\frac{(M+N)}{M(1+k-N)}\left(\frac{\sigma_0}{A}\right)^{-R}\left(\frac{\sigma_0}{K}\right)^{N}\left(1-\left(1-(1+k)\left(\frac{\sigma_0}{A}\right)^R t\right)^{\frac{1+k-N}{1+k}}\right)\right]^{\frac{M}{M+N}}$$



In the preceding expressions, D is the variable of damage corresponding to the internal variable $V9$ and r is the variable of multiplicative viscoplastic work hardening corresponding to the internal variable $V8$.

There is also the correspondence following, by reports with the parameters of the keyword VENDOCHAB :

$$N = N_{VP}$$
$$M = M_{VP}$$
$$K = K_{VP}$$
$$A = A_D$$
$$R = R_D$$
$$k = K_D$$

2.2 Sizes and results of reference

Evolution of the variable of damage, D , according to time. One tests this value at various moments:

Moment	Reference
520000	1.52596E-02
1000000	3.30676E-02
2000000	9.9465369E-02
2250000	1.37520763E-01
2500000	2.66018229E-01

Evolution of the variable of isotropic work hardening viscoplastic, r , according to time. One tests this value at various moments:

Moment	Reference
520000	2.300147E-03
1000000	3.179469E-03
2000000	4.95103E-03
2250000	5.592847E-03
2500000	6.99749E-03

The variation observed on D for $t=2.5 10^{6} s$ is due to the very strong not linearity of the evolution of the variable of damage.

2.3 Uncertainties on the solution

Precision of the codes

3 Modeling A

3.1 Characteristics of modeling

The discretization in time is rather fine:

```
( JUSQU_A = 2,          NUMBER = 10),
( JUSQU_A = 2. ,         NUMBER = 10),
( JUSQU_A = 20. ,        NUMBER = 10),
( JUSQU_A = 200. ,       NUMBER = 10),
( JUSQU_A = 2000. ,      NUMBER = 10),
( JUSQU_A = 20000. ,     NUMBER = 10),
( JUSQU_A = 200000. ,    NUMBER = 10),
( JUSQU_A = 1000000. ,  NUMBER = 30),
( JUSQU_A = 1600000. ,  NUMBER = 30),
( JUSQU_A = 1700000. ,  NUMBER = 40),
( JUSQU_A = 1800000. ,  NUMBER = 40),
( JUSQU_A = 1900000. ,  NUMBER = 40),
( JUSQU_A = 2000000. ,  NUMBER = 40),
( JUSQU_A = 2100000. ,  NUMBER = 40),
( JUSQU_A = 2200000. ,  NUMBER = 40),
( JUSQU_A = 2300000. ,  NUMBER = 40),
( JUSQU_A = 2400000. ,  NUMBER = 40),
( JUSQU_A = 2500000. ,  NUMBER = 40),
```

3.2 Characteristics of the grid

Many nodes: 8
Many meshs: 1 (HEXA8)

3.3 Sizes tested and results

Evolution of the variable of damage, D, according to time. One tests this value at various moments:

Moment	Reference
520000	1.52596E-02
1000000	3.30676E-02
2000000	9.9465369E-02
2250000	1.37520763E-01
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2250000	5.592847E-03
2500000	6.99749E-03

3.4 Remarks

The variation observed on D for $t=2.510^{6}s$ is due to the very strong not linearity of the evolution of the variable of damage.

4 Summary of the results

Results got with *Code_Aster* are close to the analytical solution of reference since the variation with the reference solution is lower than 1.2% and generally lower than 0.4% before strong non-linearity leading to the final rupture.