SSNV183 - Creep test with the model VENDOCHAB

Summarized:

The model VENDOCHAB, takes again a formulation suggested by Chaboche. It is about a coupled formulation which cover a élasto-viscoplastic model with multiplicative isotropic hardening and isotropic kinetics of damage. This model was initially developed to predict the life duration and the cracking of the paddles of the turbojets and more generally to lay down the time of failure of structures requested at high temperatures.

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

The modelization of the test-tube is realized with an element $3D$ with 8 nodes (HEXA8).

1 Problem of reference

1.1 Geometry

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

1.2 Properties of the material

the characteristics are the following ones:

Key word ELAS :

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

Key word 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:
$P=0$ to $t=0\text{s}$
$P=200\,MPa$ $t=0.1\text{s}$
$P=200\,MPa$ until $t=2.5\,10^6\,s$

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

1.4 Forced

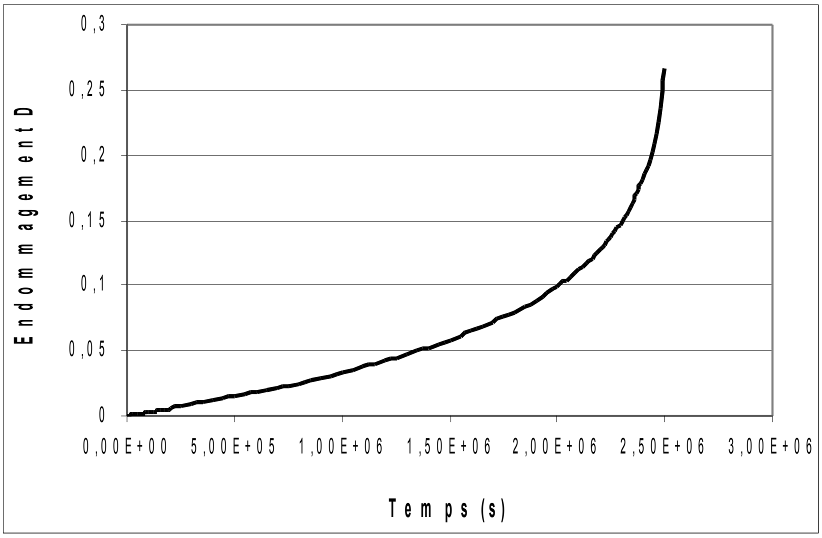
initial conditions and null strains.

2 Reference solution

2.1 analytical

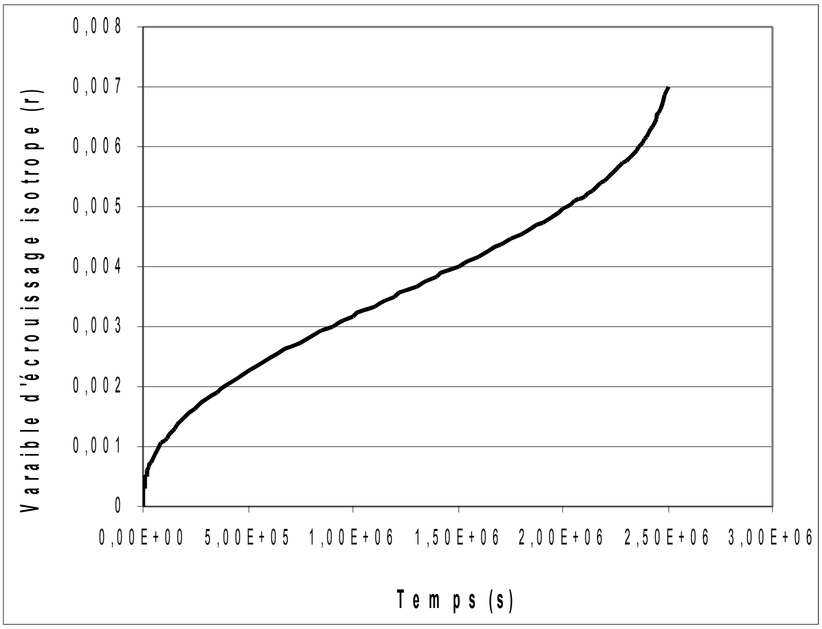
Method of calculating Solution for the variable of damage D :

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



Analytical solution for the variable of isotropic hardening viscoplastic r, in the case of a null σ_Y threshold:

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



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

There is also the correspondence following, by ratios with the parameters of key word VENDOCHAB :

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

2.2 Quantities and results of reference

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

Time	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 hardening viscoplastic r , according to time. One tests this value at various times:

Time	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

Accuracy of the codes

3 Modelization A

3.1 Characteristic of the modelization

the discretization in time is rather fine:

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( JUSQU_A = 2,          NOMBRE = 10),
( JUSQU_A = 2. ,         NOMBRE = 10),
( JUSQU_A = 20. ,        NOMBRE = 10),
( JUSQU_A = 200. ,       NOMBRE = 10),
( JUSQU_A = 2000. ,      NOMBRE = 10),
( JUSQU_A = 20000. ,     NOMBRE = 10),
( JUSQU_A = 200000. ,    NOMBRE = 10),
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( JUSQU_A = 1600000. ,  NOMBRE = 30),
( JUSQU_A = 1700000. ,  NOMBRE = 40),
( JUSQU_A = 1800000. ,  NOMBRE = 40),
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( JUSQU_A = 2200000. ,  NOMBRE = 40),
( JUSQU_A = 2300000. ,  NOMBRE = 40),
( JUSQU_A = 2400000. ,  NOMBRE = 40),
( JUSQU_A = 2500000. ,  NOMBRE = 40),
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3.2 Characteristic of the mesh

Many nodes: 8
Number of meshes: 1 (HEXA8)

3.3 Quantities tested and Evolution

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

Time	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 hardening viscoplastic r , according to time. One tests this value at various times:

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

3.4 Remarks

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.

4 Summary of the results

the 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 fracture.