SZLZ110 - Damage of Lemaître generalized in Summarized

postprocessing:

The purpose of this test is computation of the damage of Lemaître generalized "`LEMAIT_S`" from the data of the tensor of the stresses and the plastic strain cumulated at all times t_i (provided by the user).

The characteristics material E (Young modulus), ν (Poisson's ratio), S and p_d (parameters of the material) can depend on the temperature, which must thus be provided by the user at same times as the constants and the plastic strain.

1 Problem of reference

One calculates the damage $D(t)$ from the data of the tensor of the stresses $\sigma(t)$ and the cumulated plastic strain $p(t)$ resulting from a computation in thermomechanics. The kinetics of damage is given by:

$$\dot{D}=\frac{1}{(1-D)^{2s}}\left[\frac{1}{3\mathrm{ES}}(1+\nu)\sigma_{eq}^2+\frac{3}{2\mathrm{ES}}(1-2\nu)\sigma_H^2\right]^s\dot{p} \quad \text{if } p>p_d$$

$$D=0 \quad \text{not}$$

σ_{eq} is the equivalent stress of von Mises
σ_H is the hydrostatic stress
p_d represents the threshold of damage
S is a characteristic materials (MPa)
s is a characteristic materials

1.1 Materials properties

$Temp(°C)$	$E(MPa)$	ν	$S(MPa)$	P_d	s	
					Case 1	Case 2
0.	143006.0E+6	0.33	7.0	1.005E-6	0.8	1.003
20.	143006.0E+6	0.33	7.0	1.005E-6	0.8	1.003
40.	143006.0E+6	0.33	7.0	1.005E-6	0.8	1.003

Two values of the exhibitor s are successively used for the validation of the developments in `CALC_CHAMP`.

1.2 Loading

the loading corresponds to a traction test with constant temperature and imposed strainrate. It is defined in the paragraph [§2.2].

2 Reference solution

2.1 Method of calculating used for the reference solution

the reference solution is generated from option POST_FATIGUE. Adopted methodology consists in defining a load history in stresses and to recover the evolution of the cumulated plastic strain associated from a traction test $3D$ in thermo-viscoplasticity.

The load history $\sigma(t)$ and $p(t)$ is then used in a computation POST_FATIGUE with materials parameters presented to the paragraph [§1.1] to define a reference solution.

2.2 Results of Reference

result of reference of the damage of Lemaître is got for a traction test with imposed strain and constant temperature. The stress state and the cumulated plastic strain resulting from this test are the following:

Time $[s]$	Forced $Sxx(t)[Pa]$	Cumulated Plastic strain $P(t)$
50	7.15030E+06	0.000000E+00
100	1.43006E+07	0.000000E+00
150	2.14509E+07	0.000000E+00
200	2.86012E+07	0.000000E+00
250	3.57515E+07	0.000000E+00
300	4.29018E+07	0.000000E+00
350	5.00521E+07	0.000000E+00
400	5.72024E+07	0.000000E+00
450	6.43527E+07	0.000000E+00
500	7.15030E+07	0.000000E+00
550	7.86533E+07	0.000000E+00
600	8.58036E+07	0.000000E+00
650	9.29539E+07	0.000000E+00
700	1.00091E+08	9.547120E-08
750	1.06433E+08	5.747160E-06
800	1.10614E+08	2.650910E-05
850	1.12888E+08	6.060610E-05
900	1.14130E+08	1.019250E-04
950	1.14913E+08	1.464460E-04
1000	1.15508E+08	1.922890E-04

This load history is then used with operator POST_FATIGUE option LEMAIT_S to estimate the damage according to time with materials properties defined in the paragraph [§1.1]. The temperature is supposed to be constant and equalizes with $20°C$. One finds, according to the value of the parameter s used, the following damages:

	Damage (reference)	
Time $[s]$	Case $s=0.8$	Cases $s=1.003$
50	0.00000E+00	0.00000E+00
100	0.00000E+00	0.00000E+00
150	0.00000E+00	0.00000E+00
200	0.00000E+00	0.00000E+00
250	0.00000E+00	0.00000E+00
300	0.00000E+00	0.00000E+00
350	0.00000E+00	0.00000E+00
400	0.00000E+00	0.00000E+00
450	0.00000E+00	0.00000E+00
500	0.00000E+00	0.00000E+00
550	0.00000E+00	0.00000E+00
600	0.00000E+00	0.00000E+00
650	0.00000E+00	0.00000E+00
700	0.00000E+00	0.00000E+00
750	5.43732E-03	3.19264E-02
800	2.75450E-02	1.90334E-01
850	6.75939E-02	1.00000E+00
900	1.21543E-01	1.00000E+00
950	1.87318E-01	1.00000E+00
1000	2.66202E-01	1.00000E+00

2.3 Uncertainty on the solution

numerically generated Solution.

2.4 Bibliographical references

[1] A.M. DONORE: Estimate of the life duration in fatigue to great numbers of cycles and in fatigue oligocyclic. Note [R7.04.01] Index B.

3 Modelization A

3.1 Characteristic of the modelization

One uses a modelization 3D.

3.2 Characteristics of the mesh

The mesh contains 54 elements of type QUAD4 and 27 elements of type HEXA8, for a total of 64 nodes.

3.3 Quantities tested and results

One tests the values of quantities DOM_LEM.

Identification		**Reference**		**% Tolerance**	
		$s=0.8$	$s=1.003$	$s=0.8$	$s=1.003$
Point 1	Damage	0,0000000	0,0000000	0.001	0.001
Item 2	Damage	0,0000000	0,0000000	0.001	0.001
Item 3	Damage	0,0000000	0,0000000	0.001	0.001
Item 4	Damage	0,0000000	0,0000000	0.001	0.001
Item 5	Damage	0,0000000	0,0000000	0.001	0.001
Item 6	Damage	0,0000000	0,0000000	0.001	0.001
Item 7	Damage	0,0000000	0,0000000	0.001	0.001
Item 8	Damage	0,0000000	0,0000000	0.001	0.001
Item 9	Damage	0,0000000	0,0000000	0.001	0.001
Item 10	Damage	0,0000000	0,0000000	0.001	0.001
Item 11	Damage	0,0000000	0,0000000	0.001	0.001
Item 12	Damage	0,0000000	0,0000000	0.001	0.001
Item 13	Damage	0,0000000	0,0000000	0.001	0.001
Item 14	Damage	0,0000000	0,0000000	0.001	0.001
Item 15	Damage	0,0054373	0,0319264	0.001	0.001
Item 16	Damage	0,0275450	0,1903340	0.001	0.001
Item 17	Damage	0,0675939	1,0000000	0.001	0.001
Item 18	Damage	0,1215430	1,0000000	0.001	0.001
Item 19	Damage	0,1873180	1,0000000	0.001	0.001
Item 20	Damage	0,2662020	1,0000000	0.001	0.001

One calculates the rate of triaxiality of the stresses, the equivalent stress of damage, and the damage of Lemaître at the first Gauss point of the mesh M_1 :

Component	**identificatio n**	**Increment**	**Reference (NON_REGRESSION)**	**Tolerance (%)**
ENDO_ELGA	TRIAX	15	0.333333	0.1
ENDO_ELGA	SI_ENDO	15	1.06433 10-8	0.1
ENDO_ELGA	COENDO	15	5.65806 103.0.1	
ENDO_ELGA	DOM_LEM	15	5.43728 10-3	0.1

4 Summary of the results

the results provided by *Code_Aster* coincide with the values of reference.