

## SZLZ110 - Damage of Lemaître generalized in postprocessing

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### Summary:

The purpose of this test is calculation of the damage of generalized Lemaître "LEMAIT\_S" starting from the data of the tensor of the constraints and the plastic deformation cumulated at every moment  $t_i$  (provided by the user).

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

## 1 Problem of reference

The damage is calculated  $D(t)$  starting from the data of the tensor of the constraints  $\sigma(t)$  and of the cumulated plastic deformation  $p(t)$  exit of a calculation in thermomechanics. The kinetics of damage is given by:

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

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

$\sigma_{eq}$  is the equivalent constraint of von Mises

$\sigma_H$  is the hydrostatic constraint

$p_d$  represent the threshold of damage

$S$  is a characteristic materials ( MPa )

$s$  is a characteristic materials

### 1.1 Properties materials

Temp(°C)	E(MPa)	$\nu$	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 tensile test at constant temperature and speed of imposed deformation. 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 starting from the option `POST_FATIGUE`. Adopted methodology consists in defining a history of loading in constraints and to recover the evolution of the cumulated plastic deformation associated starting from a tensile test 3D in thermo-viscoplasticity.

History of loading  $\sigma(t)$  and  $p(t)$  is then used in a calculation `POST_FATIGUE` with the parameters materials presented to the paragraph [§1.1] to define a reference solution.

### 2.2 Results of Reference

The result of reference of the damage of Lemaître is got for a tensile test to imposed deformation and constant temperature. The state of stresses and the cumulated plastic deformation resulting from this test are the following:

Time [s]	Constraint $S_{xx}(t)[Pa]$	Cumulated plastic deformation $P(t)$
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 history of loading is then used with the operator `POST_FATIGUE` option `LEMAIT_S` to estimate the damage according to time with the properties materials defined in the paragraph [§1.1]. The temperature is supposed to be constant and equalizes with  $20^{\circ}C$ . One finds, according to the value of the parameter  $s$  used, following damage:

Time [s]	Damage (reference)	
	Case $s=0.8$	Case $s=1.003$
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 lifetime in fatigue to great numbers of cycles and in fatigue oligocyclic. Note [R7.04.01] Index B.

## 3 Modeling A

### 3.1 Characteristics of modeling

A modeling is used 3D.

### 3.2 Characteristics of the grid

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

### 3.3 Sizes tested and results

The values of the sizes are tested DOM\_LEM.

Identification		Reference		% Tolerance	
		s=0.8	s=1.003	s=0.8	s=1.003
Point 1	Too bad	0.000000	0.000000	0,001	0,001
Point 2	Too bad	0.000000	0.000000	0,001	0,001
Point 3	Too bad	0.000000	0.000000	0,001	0,001
Point 4	Too bad	0.000000	0.000000	0,001	0,001
Point 5	Too bad	0.000000	0.000000	0,001	0,001
Point 6	Too bad	0.000000	0.000000	0,001	0,001
Point 7	Too bad	0.000000	0.000000	0,001	0,001
Point 8	Too bad	0.000000	0.000000	0,001	0,001
Point 9	Too bad	0.000000	0.000000	0,001	0,001
Point 10	Too bad	0.000000	0.000000	0,001	0,001
Point 11	Too bad	0.000000	0.000000	0,001	0,001
Point 12	Too bad	0.000000	0.000000	0,001	0,001
Point 13	Too bad	0.000000	0.000000	0,001	0,001
Point 14	Too bad	0.000000	0.000000	0,001	0,001
Point 15	Too bad	0.0054373	0.0319264	0,001	0,001
Point 16	Too bad	0.0275450	0.1903340	0,001	0,001
Point 17	Too bad	0.0675939	1.0000000	0,001	0,001
Point 18	Too bad	0.1215430	1.0000000	0,001	0,001
Point 19	Too bad	0.1873180	1.0000000	0,001	0,001
Point 20	Too bad	0.2662020	1.0000000	0,001	0,001

One calculates the rate of triaxiality of the constraints, the equivalent constraint of damage, and the damage of Lemaître at the first point of Gauss of the mesh  $M_1$  :

Identification	Component	Increment	Reference	Tolerance ( % )
			(NON REGRESSION)	
ENDO_ELGA	TRIAX	15	0.333333	0.1
ENDO_ELGA	SI_ENDO	15	1.06433 10 <sup>-8</sup>	0.1
ENDO_ELGA	COENDO	15	5.65806 10 <sup>3</sup>	0.1
ENDO_ELGA	DOM_LEM	15	5.43728 10 <sup>-3</sup>	0.1

## 4 Summary of the results

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Results provided by Code\_Aster coincide with the values of reference.