

SSNA124 – Simulation of the behavior of a screw subjected to an irradiation at strong temperature

Summary:

This case test aims to compare the integration of the law `IRRAD3M` via the simplified study of a screw into axisymmetric. At the time of this case test the phenomena of plasticity and creep under irradiation are activated. It is a test of not-regression.

1 Problem of reference

1.1 Geometry

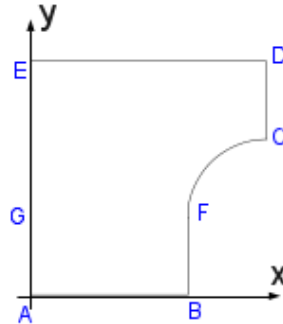


Figure 1.1-a : Geometry of the problem.

Coordinates of the points	X-coordinate (mm)	Ordinate (mm)
A	0,00	0,00
B	1,00	0,00
C	1,50	1,00
D	1,50	1,50
E	0,00	1,50
F	1,00	0,50
G	0,00	0,50

1.2 Material properties

The various properties materials are functions of the temperature in $^{\circ}C$ and of the irradiation in dpa (displacement per atom).

The parameters materials used in this case test **do not have to be used to make studies**. They do not correspond to real characteristics.

Young modulus: $E = 210000.0 - 30.0 T$ in MPa .

Poisson's ratio: $\nu = 0.30 + 5.0E-05 T$

Thermal dilation coefficient: $\alpha = (15.0 + 0.002 T) 1.0E-06$

Plastic part

$$\kappa = 0.8$$

Elastic limit with 0.2% in MPa : $R_{02} = R_{02}^0 \cdot C_{w_R_e} \cdot I_{r_R_e}$

with

$$R_{02}^0 = 270.0 - 0.65 T + 0.001 T^2$$

$$C_{w_R_e} = 3.0$$

$$I_{r_R_e} = \left(2.0 - e^{\frac{-IRRd}{3}} \right)$$

Ultimate constraint in MPa : $R_m = R_{02(T, IRR)} + (R_m^0 - R_{02}^0) \cdot C_{w_R_m} \cdot I_{r_R_m}$

with

$$R_m^0 = 600.0 - 1.5 T + 0.010 T^2$$

$$C_{w_R_m} = 0.50$$

$$I_{r_R_m} = 0.25 - 0.10 \left(1.0 - e^{-\frac{IRR}{10.0}} \right) + e^{-\frac{IRR}{2.0}}$$

Lengthening distributed: $\epsilon_u = \ln(1.0 + \epsilon_u^0 \cdot C_{w_e_u} \cdot I_{r_e_u} \cdot 1.0E-02)$

with

$$\epsilon_u^0 = 50.0 - 0.15 T + 0.0007 T^2$$

$$C_{w_e_u} = 0.25$$

$$I_{r_e_u} = e^{-\frac{IRR}{2.0}}$$

Irradiation part

$$A_{i0} = 2.2E-06 \text{ MPa}^{-1} \cdot \text{dpa}^{-1}$$

$$\eta_{is} = 700 \text{ MPa} \cdot \text{dpa}$$

Swelling part

$$R = 0.0 \text{ dpa}^{-1}$$

$$\alpha = 0.0$$

$$\phi_0 = 0.0 \text{ dpa}$$

1.3 Boundary conditions and loadings

For the edge AB , $DX=0$ $DY=0$

One applies moreover one field of temperature and irradiation with the evolutions presented below:

Moment	Temperature [°C]	Irradiation [dpa]
0,00	20,00	0,00
1,00	20,00	0,00
2,00	360,00	0,00
3,00	360,00	10,00

One proceeds to two types of calculation inside this case test. Initially, one subjects the structure to a linear pressure on the higher edge ED of value 260 N/m . This pressure is applied as of the moment $t=1$. Moreover, one imposes by connections between degrees of freedom that the edge ED a displacement has according to y identical (but unknown a priori). The objective of this first calculation is to evaluate the answer in creep of the structure.

Then, one carries out starting from the initial state a displacement imposed on the edge ED . The objective of this second calculation is to evaluate the answer in relieving of the structure.

In the case of relieving, the displacement imposed at the end of the rise in temperature ($t=2$) corresponds to that obtained with piloting in pressure for the same moment.

Imposed displacement is the following:

Moment	Displacement [mm]
0,00	0,00
1,00	3,77
2,00	17,25
3,00	17,25

2 Reference solution

2.1 Results of reference

The results of references are got with another version of *Code_Aster*, it is thus a test of not-regression.

3 Modeling A

3.1 Characteristics of modeling

The structure is modelled in elements 2D axisymmetric.

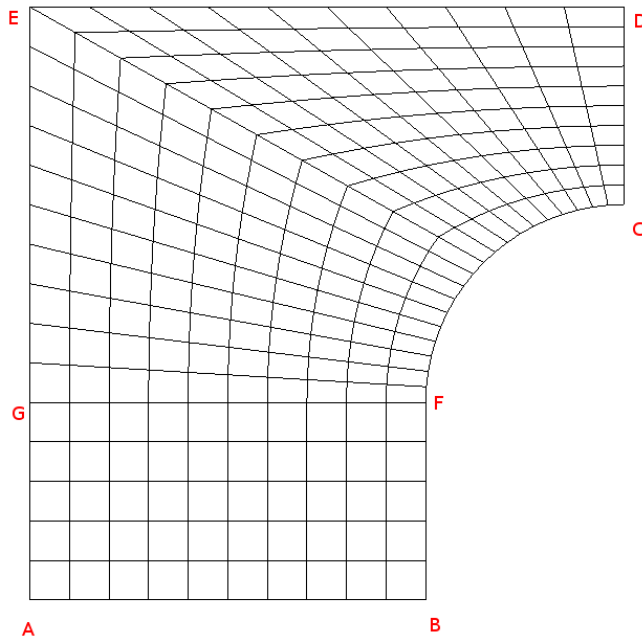


Figure 3.1-a : Grid.

3.2 Characteristics of the grid

Many nodes: 286
Many meshes and types: 250 QUAD4, 45 SEG2.

3.3 Sizes tested and results

Answer of the structure in creep: calculation number 1.

Identification	Field	Size	Reference	Tolerance
$t=2.0s$ Not E	DEPL	DY	1,40067962E-02	1.0E-04%
$t=2.1s$ Not E	DEPL	DY	1,40157903E-02	1.0E-04%
$t=2.5s$ Not E	DEPL	DY	1,75889819E-02	1.0E-04%
$t=3.0s$ Not E	DEPL	DY	2,22867046E-02	1.0E-04%
$t=2.0s$ Not E	VARI_NOEU	V1	2,82155486E-03	1.0E-04%
$t=2.1s$ Not E	VARI_NOEU	V1	2,82155486E-03	1.0E-04%
$t=2.1s$ Not E	VARI_NOEU	V2	5,70139195E+02	1.0E-04%
$t=2.5s$ Not E	VARI_NOEU	V3	5,06944859E-03	1.0E-04%
$t=3.0s$ Not E	VARI_NOEU	V3	1,27185952E-02	1.0E-04%

Answer of the structure in relieving: calculation number 2.

Identification	Field	Size	Reference	Tolerance
$t=1.0s$ Not E	SIEF_NOEU	SIYY	5,68228889E+02	1.0E-04%
$t=2.0s$ Not E	SIEF_NOEU	SIYY	5,05515873E+02	1.0E-04%
$t=2.1s$ Not E	SIEF_NOEU	SIYY	5,03413238E+02	1.0E-04%
$t=2.5s$ Not E	SIEF_NOEU	SIYY	1,05182782E+02	1.0E-04%

4 Comments

This case test makes it possible to validate the law of behavior `IRRAD3M` in a simplified study of what is its most current use with knowing a behavior in extreme request of irradiation like temperature. The results got by this case test of nonregression make it possible to validate the law in a nonelementary case.