SSNP163 – Validation of the law of behavior of steels under irradiations in plane constraints

Summary:
This elementary test aims to validate the law of behavior IRRAD3M steels under irradiations in plane constraints.

1 Problem of reference

1.1 Geometry

It is about a square plate of with dimensions $1\,mm$

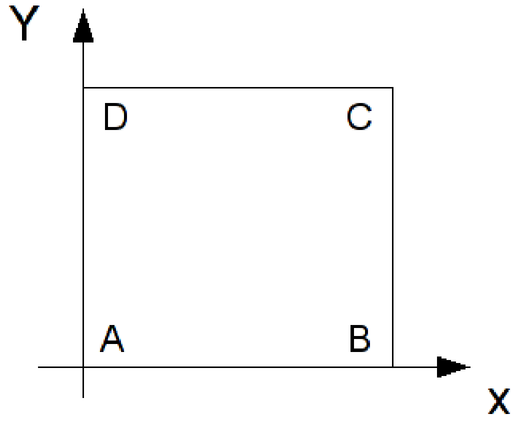

Figure 1.1-a : Geometry of the problem.

1.2 Properties materials

The various properties materials are given below.

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: $\nu=0.30+5.0\text{E-}05\,T$
Thermal dilation coefficient: $\alpha=(15.0+0.002\,T)\,1.0\text{E-}06$

Plastic part
$\kappa=0.8$

Elastic limit with 0.2% in MPa : $R_{02}=R_{02}^{0}.C_{w}\_R_{e}.I_{r}\_R_{e}$
with

$$R_{02}^{0}=270.0-0.65\,T+0.001\,T^{2}$$
$$C_{w}\_R_{e}=1.0$$
$$I_{r}\_R_{e}=\left(4.0-3.0\,e^{\frac{-IRRA}{3}}\right)$$

Ultimate constraint in MPa : $R_{m}=R_{02(T,IRRA)}+(R_{m}^{0}-R_{02}^{0}).C_{w}\_R_{m}.I_{r}\_R_{m}$
with

$$R_{m}^{0}=600.0-1.5\,T+0.010\,T^{2}$$
$$C_{w}\_R_{m}=0.50$$
$$I_{r}\_R_{m}=0.005-0.002\left(1.0-e^{\frac{-IRRA}{4.0}}\right)+e^{\frac{-IRRA}{1.8}}$$

Lengthening distributed: $\epsilon_u = \ln\left(1.0 + \epsilon_u^0 . C_{w}\_\epsilon_u . I_r\_\epsilon_u . 1.0\text{E-}02\right)$
with

$$\epsilon_u^0 = 5.0 - 0.15\,T + 0.0007\,T^2$$
$$C_w\_\epsilon_u = 1.0$$
$$I_r\_\epsilon_u = e^{-IRRA}$$

Irradiation part

$$A_{i0} = 3.0\text{E-}06\,MPa^{-1}.dpa^{-1}$$
$$\eta_{is} = 1000\,MPa.dpa$$

Swelling part

$$R = 0.0020\,dpa^{-1}$$
$$\alpha = 1.0$$
$$\phi_0 = 40.0\,dpa$$

1.3 Boundary conditions and loadings

For the edges AB and DC, $DY=0$
For the edge AD, $DX=0$
One applies moreover one linear slope of temperature having for maximum $400\,°C$ as well as a linear slope of irradiation having for maximum $140\,dpa$.

2 Reference solution

2.1 Results of reference

It is a case test of not-regression.

3 Modeling A

3.1 Characteristics of modeling

The modeling used in the case test is the following one: **Elements** **2D 'C_PLAN' (QUA4)**

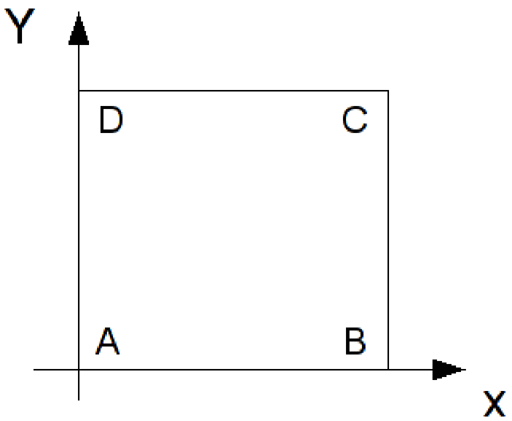

Figure 3.1-a : Geometry and grid of modeling used.

Cutting: 1 mesh QUAD4 according to the axis of x
1 mesh QUAD4 according to the axis of y

Nodes:
- A : mesh $M1$ node $N1$
- B : mesh $M1$ node $N2$
- C : mesh $M1$ node $N3$
- D : mesh $M1$ node $N4$

3.2 Characteristics of the grid

Many nodes: 4
Many meshs and types: 1 QUAD4, 3 SEG2.

3.3 Sizes tested and results

Identification	Field	Size	Reference	Tolerance
t= 20 M1 Point 1	SIEF_ELGA	SIYY	-2,20348E+02	1.0E-04%
t=120 M1 Point 1	SIEF_ELGA	SIYY	-8,73333E-04	1.0E-04%
t=160 M1 Point 1	SIEF_ELGA	SIYY	-2,22222E+02	1.0E-04%
t=200 M1 Point 1	SIEF_ELGA	SIYY	-2,22222E+02	1.0E-04%
t= 90 M1 Point 1	VARI_ELGA	V1	4,76458E-03	1.0E-04%
t=100 M1 Point 1	VARI_ELGA	V1	5,38907E-03	1.0E-04%
t=110 M1 Point 1	VARI_ELGA	V2	1,30893E+03	1.0E-04%
t=200 M1 Point 1	VARI_ELGA	V2	2,31584E+04	1.0E-04%
t=200 M1 Point 1	VARI_ELGA	V4	6,66667E-02	1.0E-04%
t=110 M1 Point 1	VARI_ELGA	V3	9,26799E-04	1.0E-04%
t=200 M1 Point 1	VARI_ELGA	V3	6,64753E-02	1.0E-04%

4 Comments

This case test makes it possible to make sure of the perenniality of the results resulting from the law from behavior IRRAD3M in plane constraints.