EPICU01 - Validation of the order POST_K_BETA

Summary:

This test validates the operation of the order POST_K_BETA who calculates the stress intensity factors to the two points of defects, using the constraints with the nodes resulting from the mechanical resolution.

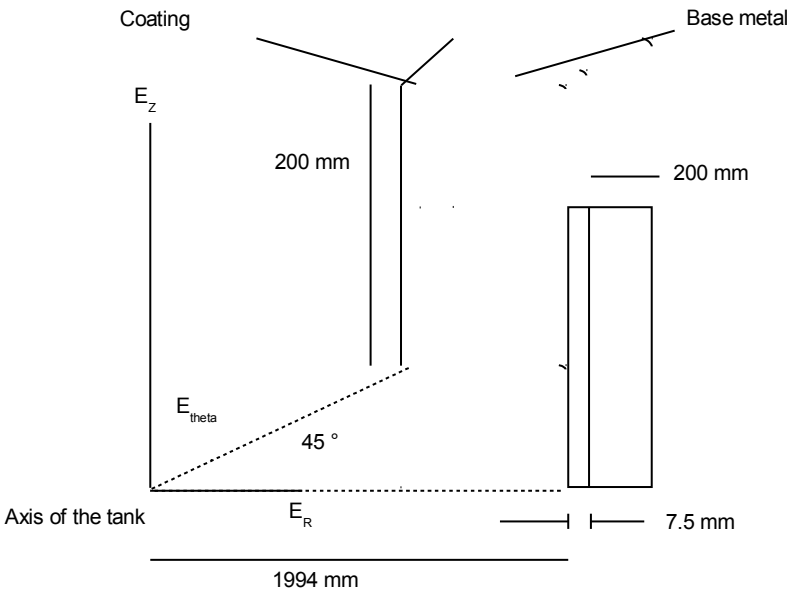
This test breaks up into two types of modeling:

- EPICU01a: axisymmetric modeling,
- EPICU01b: modeling 3D .

1 Problem of reference

1.1 Geometry

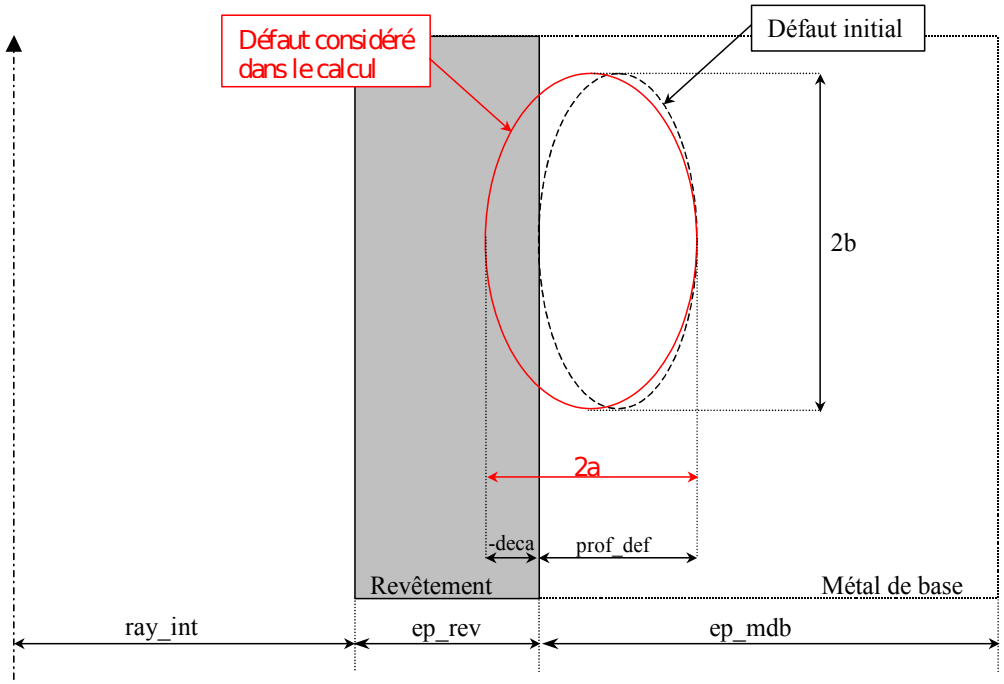
The studied geometry is that of a slice of tank bimetal, limited to 45 degrees in azimuth.



1.1.1 Defect considered

In the method $K\beta$, the defect is not modelled in the grid. The grid makes it possible to calculate the constraints with the nodes. A postprocessing is then applied to calculate the factor of intensity of the constraints by the method β starting from the constraints with the nodes (the method is detailed in [R7.02.10]).
For this test, the defect considered is elliptic and of longitudinal orientation. Its dimensions are the following ones (see figure which follows):

- depth: $prof_{\text{def}} = 6\text{mm}$
- width: $2b = 60\text{mm}$
- shift in the coating: $deca = -0{,}2\,mm$



Axe de la cuve

1.2 Material properties

For calculation in thermics:

Two properties are indicated, it acts of:

- LAMBDA : thermal conductivity isotropic function of the temperature, expressed in $W.m^{-1}.K^{-1}$,
- BETA : voluminal enthalpy according to the temperature, expressed in $J.m^{-3}$.

For the coating:

Temperature ($°C$)	LAMBDA
0	14.7
20	14.7
50	15.2
100	15.8
150	16.7
200	17.2
250	18
300	18.6
350	19.3

Temperature ($°C$)	BETA
0	0.000000.E+00
50	1.102100.E+08
100	3.013300.E+08
150	5.014300.E+08
200	7.081300.E+08
250	9.188800.E+08

300	1.132910.E+09
350	1.348980.E+09

For the base metal:

Temperature ($°C$)	LAMBDA
0	37.7
20	37.7
50	38.6
100	39.9
150	40.5
200	40.5
250	40.2
300	39.5
350	38.7

Temperature ($°C$)	BETA
0	0.000000.E+00
50	1.061900.E+08
100	2.903300.E+08
150	4.829100.E+08
200	6.832800.E+08
250	8.921600.E+08
300	1.109440.E+09
350	1.335060.E+09

For calculation in mechanics:

Four parameters are indicated, it acts of:

- E : Young modulus, expressed in Pa ,
- $nu=0.3$ Poisson's ratio,
- ALPHA: isotropic thermal dilation coefficient, expressed in $°C$,
- TEMP_DEF_ALPHA = 20: value of the temperature to which values of the thermal dilation coefficient ALPHA were determined, expressed in $°C$.

For the coating:

Temperature ($°C$)	E
0	1.985E+11
20	1.97E+11
50	1.95E+11
100	1.915E+11
150	1.875E+11
200	1.84E+11
250	1.8E+11
300	1.765E+11
350	1.72E+11

Modeling has

Temperature ($°C$)	ALPHA
0	1.756E-05
20	1.764E-05
50	1.7787E-05
100	1.8019E-05
150	1.8225E-05
200	1.8575E-05
250	1.8568E-05
300	1.8768E-05

Modeling B

Temperature ($°C$)	ALPHA
20	1.64E-05
50	1.654E-05
100	1.68E-05
150	1.704E-05
200	1.72E-05
250	1.75E-05
300	1.777E-05

For the base metal:

Temperature ($°C$)	E
0	2.05E+11
20	2.04E+11
50	2.03E+11
100	2E+11
150	1.97E+11
200	1.93E+11
250	1.89E+11
300	1.85E+11
350	1.8E+11

Modeling A

Temperature ($°C$)	ALPHA
0	1.2878E-05
20	1.3002E-05
50	1.3198E-05
100	1.3521E-05
150	1.382E-05
200	1.4102E-05
250	1.4382E-05
300	1.4682E-05

Modeling B

Temperature ($°C$)	ALPHA
20	1.122E-05
50	1.145E-05
100	1.179E-05
150	1.214E-05
200	1.247E-05
250	1.278E-05
300	1.308E-05

1.3 Boundary conditions and loadings

The boundary conditions imposed are those of an axisymmetric system.

Two types of loadings are applied:

- heat exchange in internal skin,
- fluid pressure in internal skin.

2 Reference solution

2.1 Results of reference

The results of reference are those resulting from a similar calculation carried out starting from code CUVE1D. The case 3D treated here is identical to the similar simulation 1D obtained with version 2.1 of CUVE1D, which is used as reference.

These calculations carried out with CUVE1D are detailed in the note of validation of this software: “CUVE1D Version 2 - Note of validation” H-T26-2007-00833-FR.

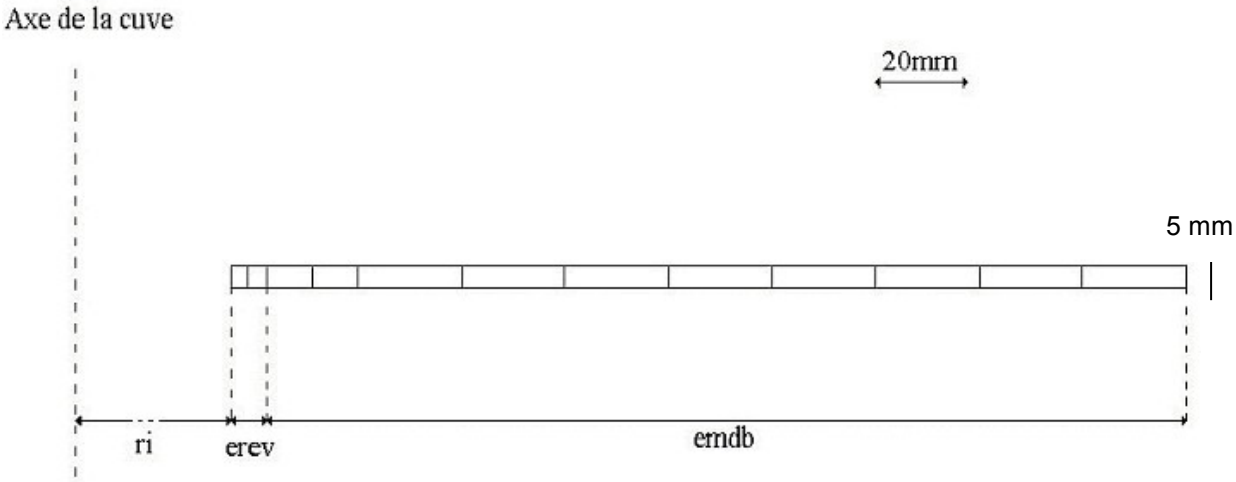
2.2 Uncertainty on the solution

Uncertainties on the reference solution are estimated at 2% .

3 Modeling A

3.1 Characteristics of modeling

Modeling 2D , axisymetic (SEG3, QUAD8)



3.2 Characteristics of the grid

Many nodes: 63
Many elements: 26 SEG3, 12 QUAD8.

3.3 Sizes tested and results

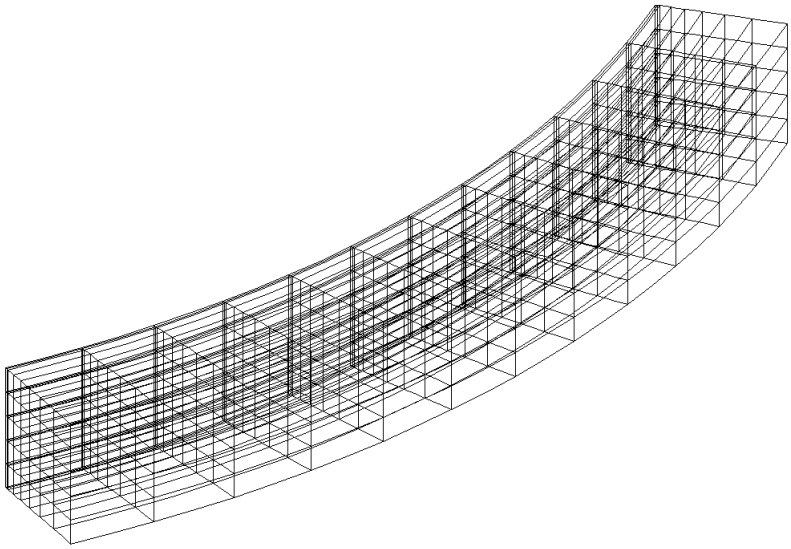
Below and in complementary test of not-regression, the comparison of the results *Aster* compared to the results of reference resulting from the computer code CUVE1D in version 2.1:

Type of value	Moment	Reference	% Tolerance
K1_REV	0	1.5187E+07	1.0
KCP_REV	0	1.818E+07	1.0
TEMPPF_REV	0	287	1.0
K1_MDB	0	1.5223E+07	1.0
KCP_MDB	0	2.0223E+07	1.0
TEMPFF_MDB	0	287	1.0
K1_REV	3871	9.462E+06	1.0
KCP_REV	3871	2.6737E+07	1.0
TEMPPF_REV	3871	84.88	1.0
K1_MDB	3871	4.29E+06	1.0
KCP_MDB	3871	2.9246E+07	1.0
TEMPFF_MDB	3871	86.05	1.0

4 Modeling B

4.1 Characteristics of modeling

Modeling 3D **(SEG3, QUAD8, HEXA20)**



4.2 Characteristics of the grid

Many nodes: 1667
Many elements: 40 SEG3, 312 QUAD8, 288 HEXA20

4.3 Sizes tested and results

Below and in complementary test of not-regression, the comparison of the results *Aster* compared to the results of reference resulting from the computer code CUVE1D in version 2.1:

Type of value	Moment	Reference	% Tolerance
K1_REV	3871	9.407E+06	1.5
KCP_REV	3871	25.167E+06	1.5
TEMPPF_REV	3871	84.88	1.5
K1_MDB	3871	3.585E+06	1.5
KCP_MDB	3871	25.894E+06	1.5
TEMPFF_MDB	3871	86.04	1.5

5 Summary of the results

This case test validates the order POST_K_BETA for the first type of modeling.