HSLA303 - Roll under pressure and thermal thermal expansion

Abstract:

The computation is realized into axisymmetric. The goal of the test is to validate the predeformations (key word `PRE_EPSI`).

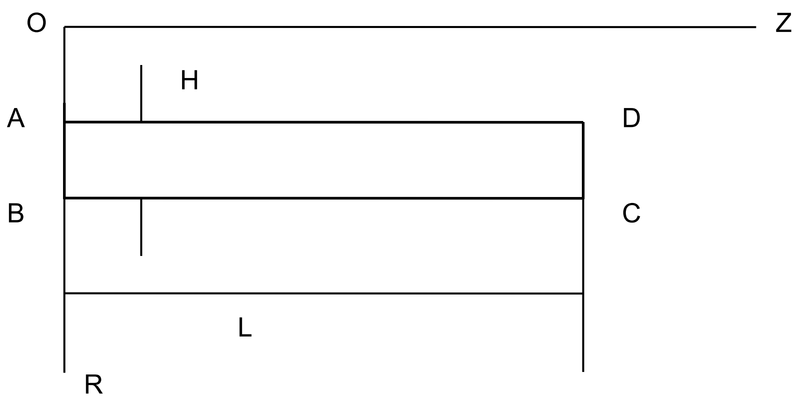
The cylinder is subjected to a homogeneous thermal thermal expansion (ΔT constant).

The followed procedure is the following one:

- either ε_1 the strain field exits of one the 1st computation, the cylinder being subjected to a homogeneous thermal thermal expansion ΔT (U_1 the field of resulting displacements),
- in the second computation, the cylinder is subjected to an internal pressure, with as predeformations the strain field ε_1 (or U_2 the resulting field of displacements),
- one then compares the results with the field U, obtained with cylinder under pressure, but without predeformations. One must have the relation: $U_2=U+U_1$.

1 Problem of reference

1.1 Geometry



Length: $L=1\,m$
Thickness: $h=0.0025\,m$
External radius: $\mathrm{Re}=0.05\,m$

1.2 Material properties

$E=2.1\times 10^{11}\,Pa$

$\nu=0.3$

$\alpha=0.12\,x\,10^{-4}/°C$

1.3 Boundary conditions and loadings

- Section AB out of bearing (direction z),
- thermal Thermal expansion in the thickness (computation 1): $\Delta T=100\,°C$
- Pressure interns (computation 2): $p=2\times 10^{8}\,N/m^{2}$
- Taking into account of the basic effect.

1.4 Initial conditions

Without object for the static analysis.

2 Reference solution

2.1 Method of calculating used for the reference solution

- the strain due to direct compression is given by:

$$\varepsilon_{zz}=\frac{(1-2\nu)(2R_e-h)}{4\mathrm{Eh}}p=3.714\times10^{-3}\ ,\ R_e=\ \text{external radius}$$

- axial displacement due to the pressure is given by:

$$U_z=Z\,\varepsilon_{zz}$$

- The strains due to the thermal loading are worth:

$$\varepsilon_{rr}=\varepsilon_{\theta\theta}=\varepsilon_{zz}=\alpha\,\Delta T=1.2\times10^{-3}$$

- Radial displacement due to the thermal loading is worth:

$$U_r=r\,\varepsilon_{rr}=1.2\times10^{-3}r$$

2.2 Results of reference

- Strain and radial displacement and axial with the points A, B, C, D due to the thermal loading.
- Strain and axial displacement at the points A, B, C, D due to the pressure.

2.3 Uncertainty on the analytical

solution Solution.

3 Modelization A

3.1 Characteristic of the modelization

AXIS, mesh $Q8$

Cutting: 10 elements according to length
1 element in the thickness

limiting Conditions:

in A , B

```
DDL_IMPO = (GROUP_NO = "A", DY = 0. )
DDL_IMPO = (GROUP_NO = "B", DY = 0. )
```

Pressure + basic effect: field U

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PRES_REP:          (GROUP_MA = cont_pr, NEAR = 2.E8)
FORCE_CONTOUR:     (GROUP_MA = effond  , FY = 1.95E9)
```

thermal Thermal expansion: field U_1

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char_no:
CREA_CHAMP         (AFFE = (TOUT = "YES", NOM_CMP = "TEMP", VALE = 100.))


char_th:
AFFE_MATERIAU      (AFFE_VARC = F (TOUT = "YES", CHAM_GD = CHAR_NO, VALE_REF
                   = 0. , NOM_VARC = "TEMP",  )
```

Predeformations: field U_2

```
PRE_EPSI:          (TOUT = "YES", EPXX = 1.2E-3, EPYY = 1.2E-3,
                   EPZZ = 1.2E-3,  EPXY = 0.)
```

Names of the nodes:

$A=N1$ $B=N2$ $C=N3$ $D=N4$

3.2 Characteristics of the mesh

Many nodes: 53

Number of meshes and types: 10 QUAD8, 22 SEG3

3.3 Quantities tested and Results

results concerning the fields U_1 U_2 , U

Field	**Localization**	**Variables**	**Reference**	***Aster***	**% thermal**
Reference Field U_1	A	$Ur(DX)$	5.7 X 10-5	5.7 X 10-5	-6.42 X 10-11
	B	$Ur(DX)$	6 X 10-5	6 X 10-5	-7.14 X 10-11
	C	$Ur(DX)$	6 X 10-5	6 X 10-5	8.29 X 10-12
		DY	1.2 X 10 $^{-3.1.2}$	X 10 $^{-3.3.9}$	X 10-10
	D	$Ur(DX)$	5.7 X 10-5	5.7 X 10-5	1.19 X 10-11
		$U(DY)$	1.2 X 10 $^{-3.1.2}$	X 10-3	3.9 X 10-10
	A , mesh $M1$	ε_{rr}	1.2 X 10 $^{-3.1.2}$	X 10 $^{-3}$	-1.91 X 10-10
		$\varepsilon_{\theta\theta}$	1.2 X 10-3	1.2 X 10-3	5.54 X 10-10
		ε_{zz}	1.2 X 10 $^{-3.1.2}$	X 10 $^{-3}$	-1.12 X 10-10
	B , mesh $M1$	ε_{rr}	1.2 X 10 $^{-3.1.2}$	X 10 $^{-3}$	-1.89 X 10-10
		$\varepsilon_{\theta\theta}$	1.2 X 10-3	1.2 X 10-3	5.57 X 10-10
		ε_{zz}	1.2 X 10 $^{-3.1.2}$	X 10 $^{-3}$	-1.16 X 10-10
	C , mesh $M10$	ε_{rr}	1.2 X 10 $^{-3.1.2}$	X 10 $^{-3}$	-3.74 X 10-11
		$\varepsilon_{\theta\theta}$	1.2 X 10-3	1.2 X 10-3	1.08 X 10-10
		ε_{zz}	1.2 X 10 $^{-3.1.2}$	X 10 $^{-3}$	-4.74 X 10-12
	D , mesh $M10$	ε_{rr}	1.2 X 10 $^{-3.1.2}$	X 10 $^{-3}$	-3.98 X 10-11
		$\varepsilon_{\theta\theta}$	1.2 X 10-3	1.2 X 10-3	1.12 X 10-10
		ε_{zz}	1.2 X 10 $^{-3.1.2}$	X 10 $^{-3}$	-2.93 x10-12
Field of pressure U	C	$U_\theta(DY)$	3.714 X 10 $^{-3}$	3.997 X 10 $^{-3}$	7.614
	D	$U_\theta(DY)$	3.714 X 10 $^{-3}$	3.997 X 10-3	7.614
	C , mesh $M10$	$\varepsilon_{\theta\theta}$	3.714 X 10-3	3.996 X 10-3	7.602
	D , mesh $M10$	$\varepsilon_{\theta\theta}$	3.714 X 10-3	3.996 X 10-3	7.602
Field U_2	C	$U_{\theta\theta}$	4.914 X 10 $^{-3}$	5.197 X 10 $^{-3}$	5.754
	D	$U_{\theta\theta}$	4.914 X 10-3	5.197 X 10-3	5.754
	C , mesh	$\varepsilon_{\theta\theta}$	4.914 X 10-3	5.196 X 10-3	5.746
	D , mesh	$\varepsilon_{\theta\theta}$	4.914 X 10-3	5.196 X 10-3	5.746

3.4 Remarks

- the goal of the test are not to obtain a high degree of accuracy on the level of the results, but simply to check the relation: $U_2 = U + U_1$; so computation was carried out only with one coarse mesh.
- It is noted that the required relation is well checked at the loose lead of the cylinder.
- It is checked in addition that the strain field resulting from thermal thermal expansion is uniformly equal to 1.2×10^{-3} .

4 Summary of the results

option PRE_EPSI (predeformations into constant) provides completely satisfactory results.