SSNA301 - Fund of Summarized pressurized thick

tank:

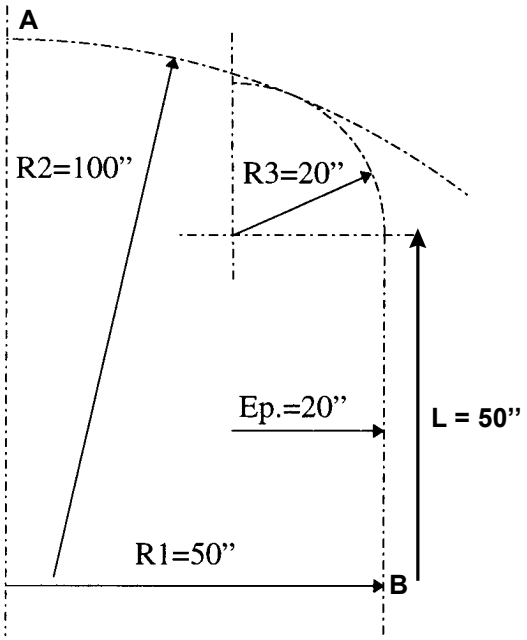
This test consists in analyzing until failure, the spherotoric bottom of a thick tank subjected to an internal pressure in taking into account the elastoplastic behavior of the material and the nonlinear behavior of structure.

The modelization is made with axisymmetric elements of type MEAXQU8.

One will test the taking into account here or not geometric nonlinearities and the use of one or two assumptions material.

1 Problem of reference

1.1 Geometry



1.2 Material properties

elastoplastic Material without hardening

$E = 3.\mathrm{E}+07\ MPa$
$\nu = 0.3$
$\sigma_y = 3.\mathrm{E}+04\ MPa$

1.3 Boundary conditions and loadings

Point: $A \quad u_x = 0$
Point: $B \quad u_y = 0.$

The setting charges some (= pressure interns) following is applied:

$p = 1.737\ p_0$ (vicinity of failure) with $p_0 = 658.257\ MPa$ (end of the linear mode)

the load p is applied in 50 identical increments.

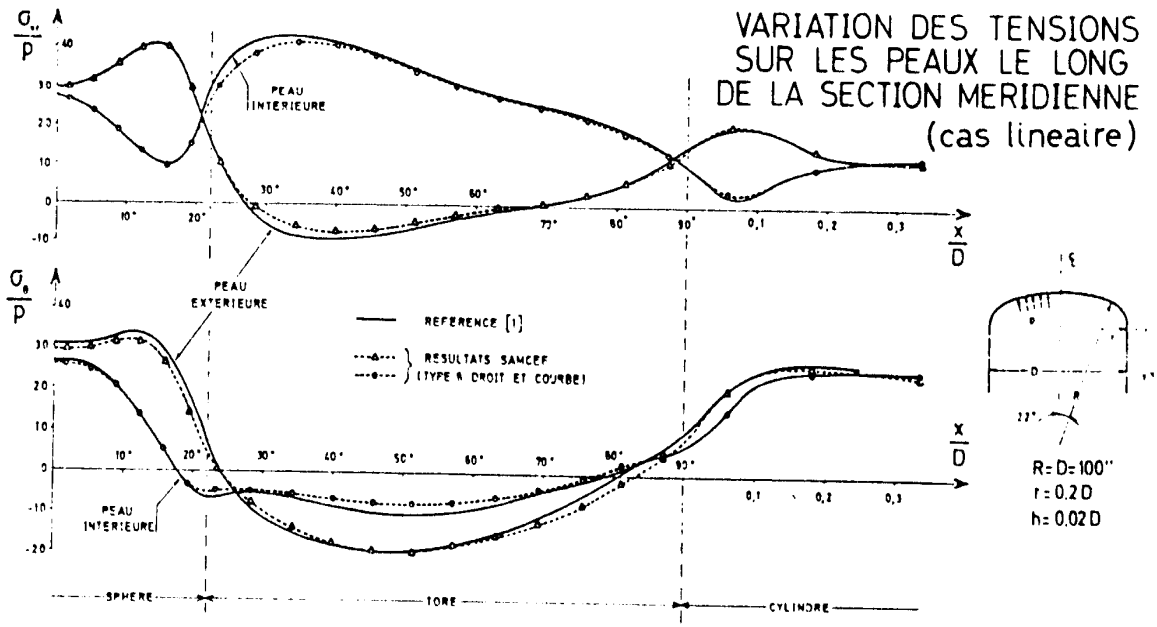
2 Reference solution

2.1 Method of calculating used for the reference solution

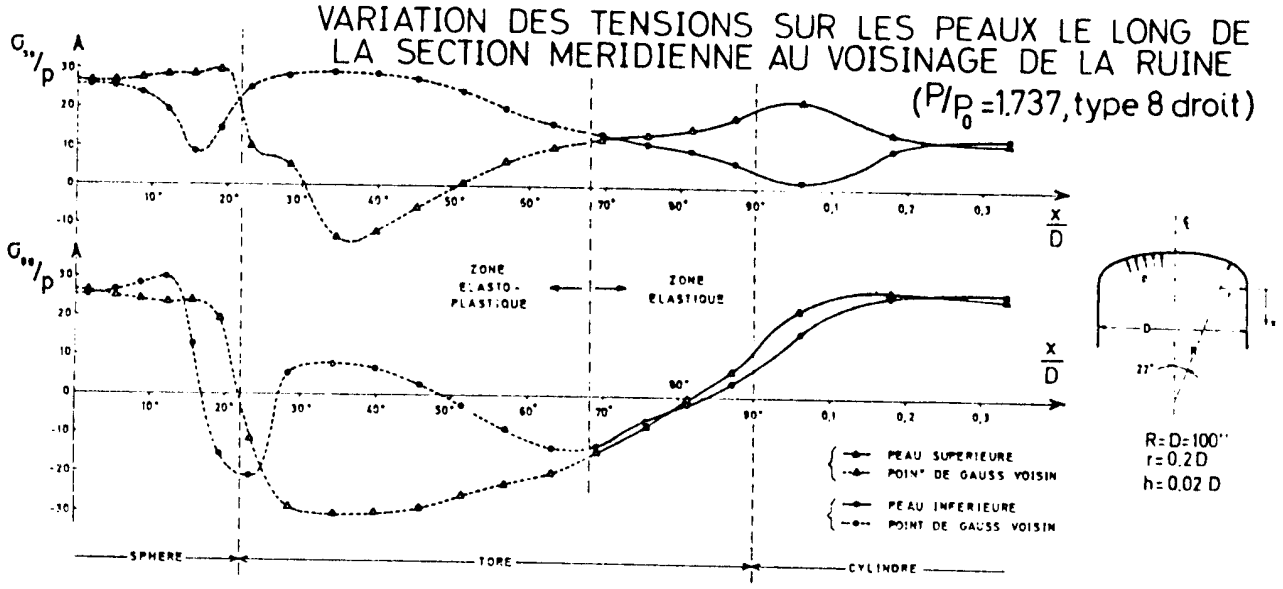
Computation finite element with the SAMCEF software Version 7.0 (Mecanl).

2.2 Reference solution

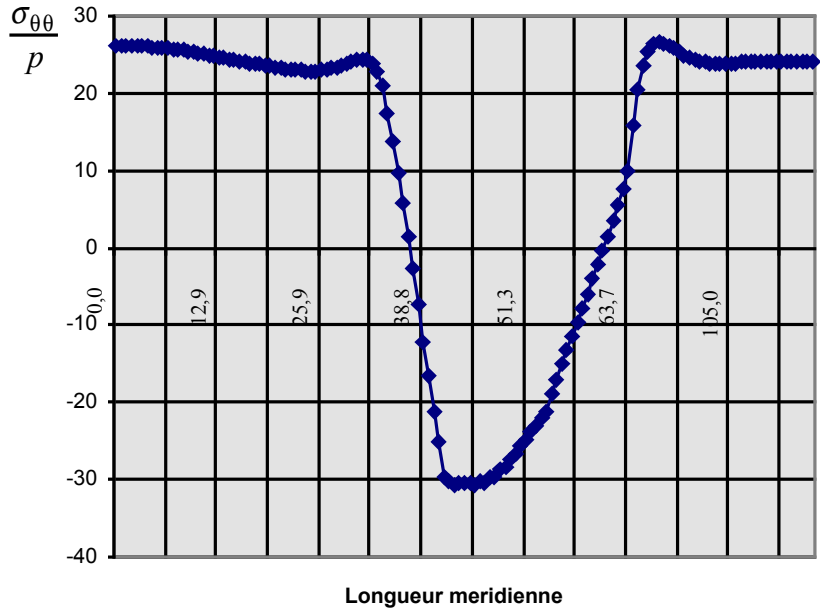
Variation of the tensions on the skins along the meridian section for a pressure interns p_0 [bib2]



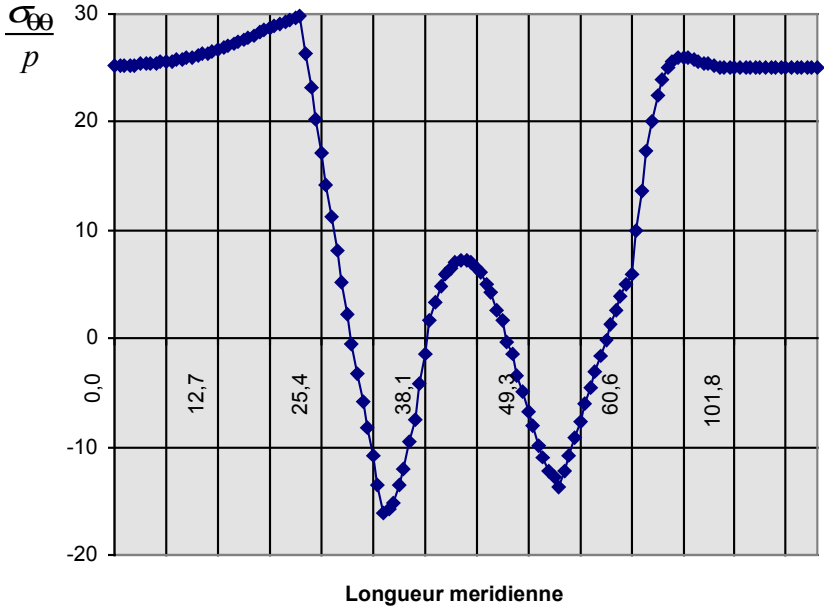
Variation of the tensions on the skins along the meridian section in the vicinity of failure for a pressure interns p_{max} [bib2]



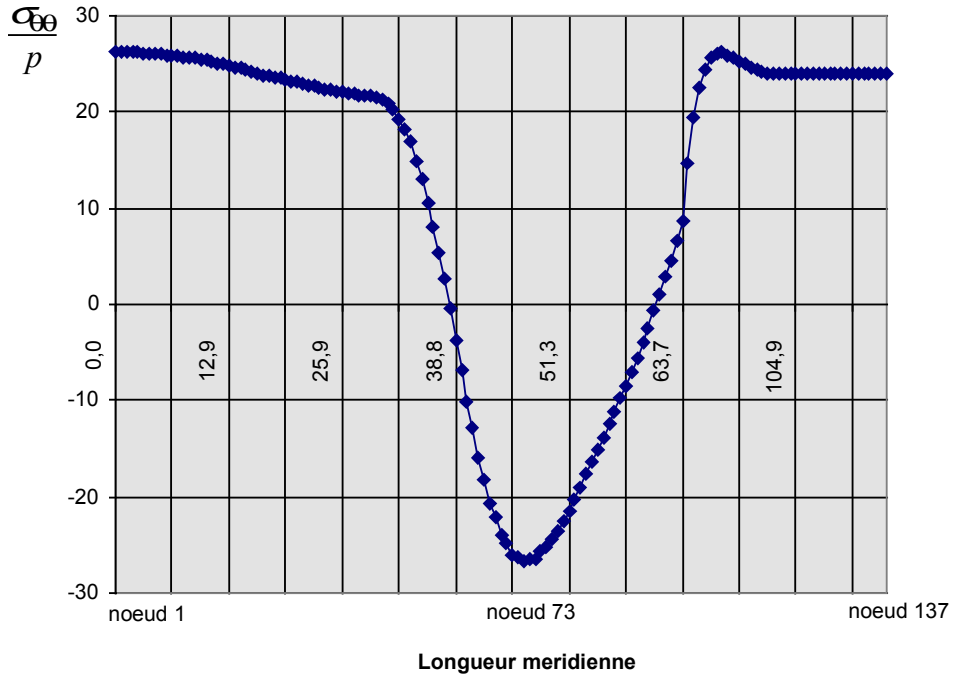
Variation of the azimuth stress $\sigma_{\theta\theta}$ on the skin higher along the meridian section in the vicinity of failure for an internal pressure p_{max} . Geometrical linear computation.



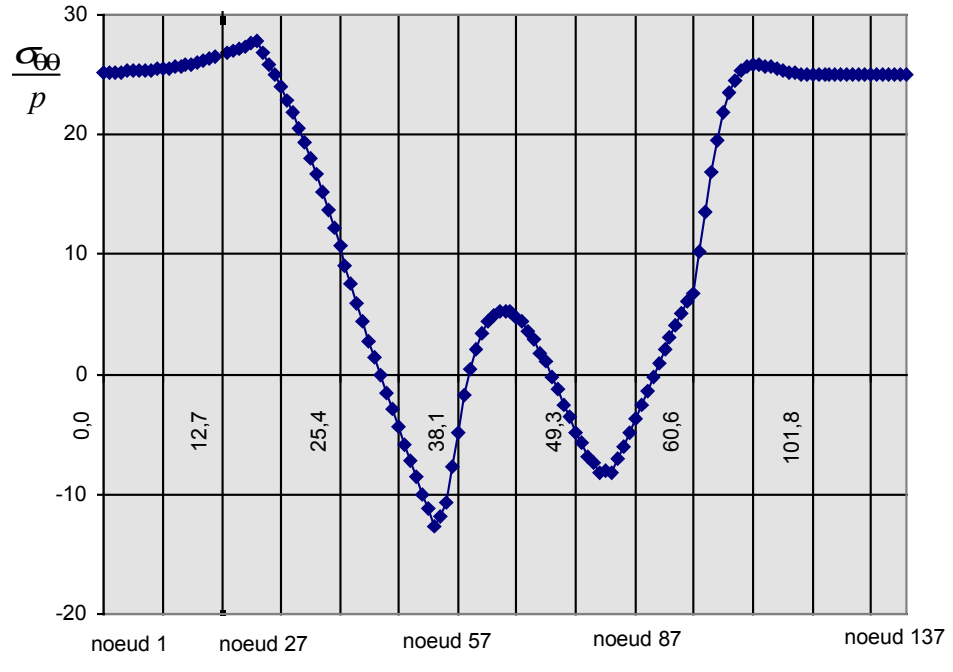
Variation of the azimuth stress $\sigma_{\theta\theta}$ on the skin lower along the meridian section in the vicinity of failure for an internal pressure p_{max} . Geometrical linear computation.

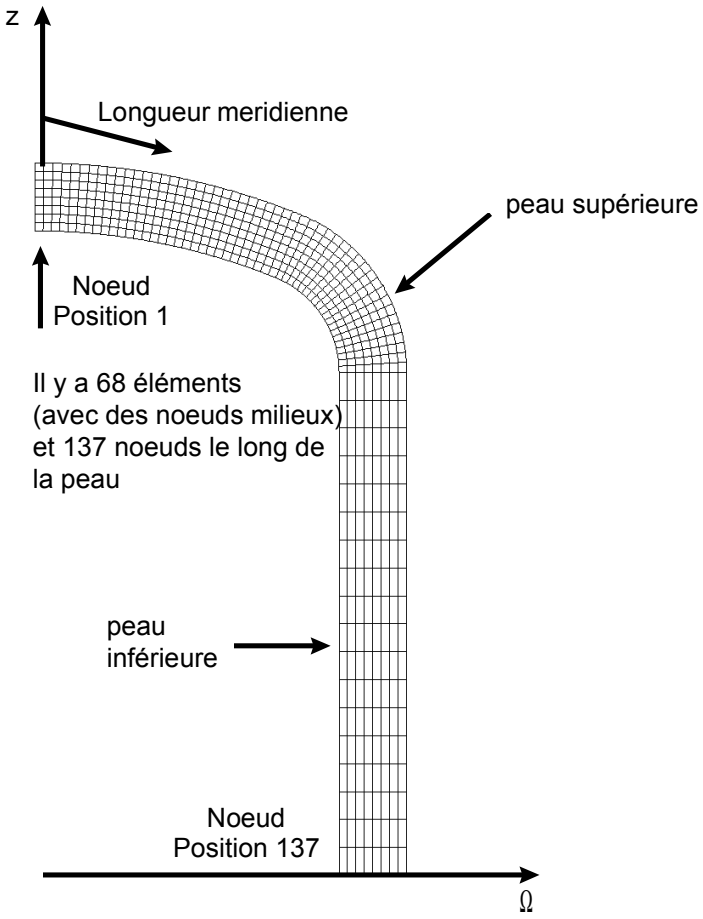


Variation of the azimuth stress $\sigma_{\theta\theta}$ on the skin higher along the meridian section in the vicinity of failure for an internal pressure p_{max} . Geometrical nonlinear computation.



Variation of the azimuth stress $\sigma_{\theta\theta}$ on the skin lower along the meridian section in the vicinity of failure for an internal pressure p_{max} . Geometrical nonlinear computation.





Discretization used for the reference solution. Definition of the axes

geometrical nonlinear Computation: $pression = p_{max}$

Skin	meridian Length $(inch)$	Higher Position	$\frac{\sigma_{\theta\theta}}{p}$
	node	0.0	1
26.223	46.298	73	– 26.688
	137.9	137	24.103
	0.0	1	25.231
	16.491	27	27.909
Lower	35.518	57	– 12.711
	52.707	87	– 8.1652
	134.76	137	25.103

geometrical linear Computation: $pression = p_{max}$

Skin	meridian Length $(inch)$	Higher Position	$\frac{\sigma_{\theta\theta}}{p}$
	node	0.0	1
26.2	45.1	71	– 30.7
	138.137		24.0
	0.0	1	25.231
	22.833	37	29.899
Lower	32.981	53	– 16.127
	52.707	87	– 13.756
	134.76	137	25.008

Field of displacement (not A , lower skin)

Computation… geometrical	meridian Length $(inch)$	Position node	Nonlinear	Pressure U^Z $(inch)$
Linear	Displacement	0.0	$0.5\ pmax$	1
	0.100945	0.0	$pmax$	1
0.370468	0.0	1	$0.5\ pmax$	0.0990524
	0.0	1	$pmax$	0.244347

2.3 Uncertainty on the solution

Uncertainty lower than $2\ \%$ (linear mode), lower than $5\ \%$ (elastoplastic mode).

2.4 Bibliographical references

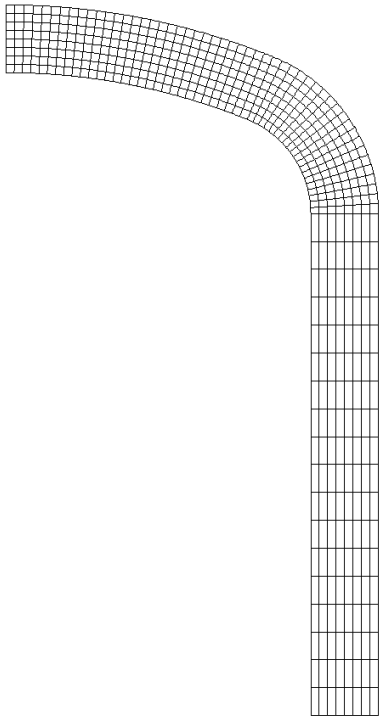
•LARSEN, P.K., POPOV, E.P., Elastic-plastic analysis of thick-walled presses vessels with sharp discontinuities, Trans. ASME Applied Mechanics, pp 1016-1019, 1971

•NYSSEN, C., Modelization by finite elements of the nonlinear aerospace structure behavior, thesis of doctorate, University of Liege, 1979

3 Modelization A

3.1 Characteristic of the modelization A

Nonlinear material + linear geometrical



3.2 Characteristics of the mesh

Many nodes: 2197
Number of meshes and types: 544 MEAXQU8 (diagram of integration 3 X 3) + 68 SEG3 (68 meshes on the length (30 on the part with a radius of 100 ' ", 20 on the part with a radius of 20" "and 18 on the right part) and 8 on L" thickness)

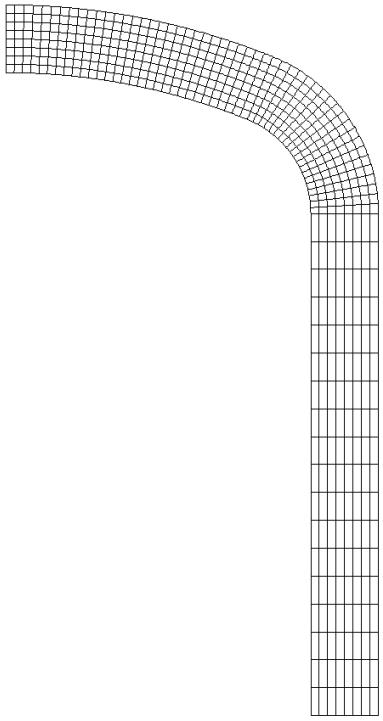
3.3 Quantities tested and results

Identification	Reference	*Aster*	% difference
Long SIZZ/p Skin sup. Merid=0. p=pmax	26.2	26.218	0.071
Long SIZZ/p Skin sup. Merid=45.1 p=pmax	– 30.7	– 30.531	– 0.553
Long SIZZ/p Skin sup. Merid=138 p=pmax	24.0	24.011	– 0.553
Long SIZZ/p Skin inf. Merid=0. p=pmax	25.231	25.229	– 0.553
Long SIZZ/p Skin inf. Merid=22.833 p=pmax	29.899	29.957	– 0.553
Long SIZZ/p Skin inf. Merid=32.981 p=pmax	– 16.127	– 16.294	– 0.553
Long SIZZ/p Skin inf. Merid=52.707 p=pmax	– 13.756	– 13.699	– 0.553
Long SIZZ/p Skin inf. Merid=134.76 p=pmax	25.008	25.012	– 0.553
DY node 2313 with p=0.5 pmax	0.100945	0.100946	0.002
DY node 2313 with pmax	0.370468	0.370470	0.001

4 Modelization B

4.1 Characteristic of the modelization B

Nonlinear material + nonlinear geometrical



4.2 Characteristics of the mesh

Many nodes:	2197
Number of meshes and types:	544 MEAXQU8 (diagram of integration 3 X 3) + 68 SEG3 (68 meshes on the length (30 on the part with a radius of 100 ' “, 20 on the part with a radius of 20” “and 18 on the right part) and 8 on L” thickness)

4.3 Quantities tested and results

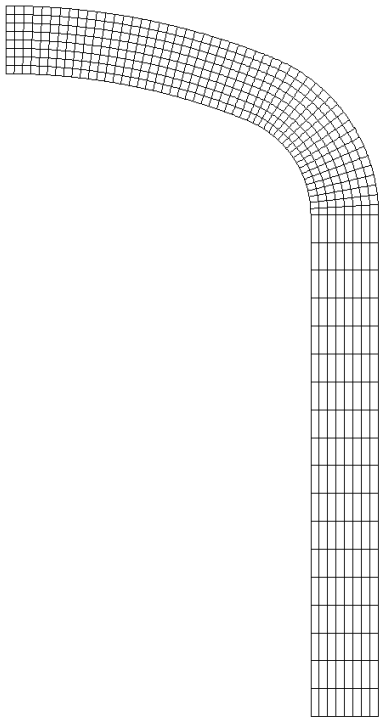
Identification	Reference	Aster	% difference
Long SIZZ/p Skin sup. Merid=0. p=pmax	26.223	26.299	0.025
Long SIZZ/p Skin sup. Merid=45.298 p=pmax	– 26.688	– 27.156	1.756
Long SIZZ/p Skin sup. Merid=137.9 p=pmax	24.103	24.018	– 0.352
Long SIZZ/p Skin inf. Merid=0. p=pmax	25.231	25.236	0.021
Long SIZZ/p Skin inf. Merid=16.491 p=pmax	27.909	28.086	0.638
Long SIZZ/p Skin inf. Merid=35.518 p=pmax	– 12.711	– 13.095	3.026
Long SIZZ/p Skin inf. Merid=52.707 p=pmax	– 8.1652	– 8.426	3.196
Long SIZZ/p Skin inf. Merid=134.76 p=pmax	25.103	25.018	– 0.337
DY node 2313 with p=0.5 pmax	0.099052	0.099191	0.141
DY node 2313 with pmax	0.244347	0.246979	1.077

5 Modelization C

5.1 Characteristic of the modelization C

All meshes have a nonlinear material behavior, except the 8x5 meshes of the lower part of structure (this part does not plasticize) which have a linear material behavior.

A geometrical linear analysis is carried out.



5.2 Characteristics of the mesh

Many nodes:	2197
Number of meshes and types:	544 MEAXQU8 (diagram of integration 3 X 3) + 68 SEG3 (68 meshes on the length (30 on the part with a radius of 100 ' “, 20 on the part with a radius of 20” “and 18 on the right part) and 8 on L” thickness)

5.3 Quantities tested and results

Identification	Reference	Aster	% difference
Long SIZZ/p Skin sup. Merid=0. p=pmax	26.2	26.218	0.071
Long SIZZ/p Skin sup. Merid=45.1 p=pmax	– 30.7	– 30.531	– 0.553
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Long SIZZ/p Skin inf. Merid=0. p=pmax	25.231	25.229	– 0.553
Long SIZZ/p Skin inf. Merid=22.833 p=pmax	29.899	29.957	– 0.553
Long SIZZ/p Skin inf. Merid=32.981 p=pmax	– 16.127	– 16.294	– 0.553
Long SIZZ/p Skin inf. Merid=52.707 p=pmax	– 13.756	– 13.699	– 0.553
Long SIZZ/p Skin inf. Merid=134.76 p=pmax	25.008	25.012	– 0.553
DY node 2313 with p=0.5 pmax	0.100945	0.100946	0.002
DY node 2313 with pmax	0.370468	0.370470	0.001

6 Summary of the results

the results provided by Aster concerning the modelizations A and C are close to the reference (variation $< 0.6\%$). Moreover, one finds well the same results for the modelizations A and C; what is normal because the lower part remains elastic.

For the modelization B, the differences of results between *Code_Aster* and reference (the SAMCEF software) reach $3.3\ \%$ and come owing to the fact that the geometric nonlinearities are treated in a different way in *Code_Aster* (by the command PETIT_REAC) and the SAMCEF software.