SSNA301 - Fund of pressurized thick tank

Summary:

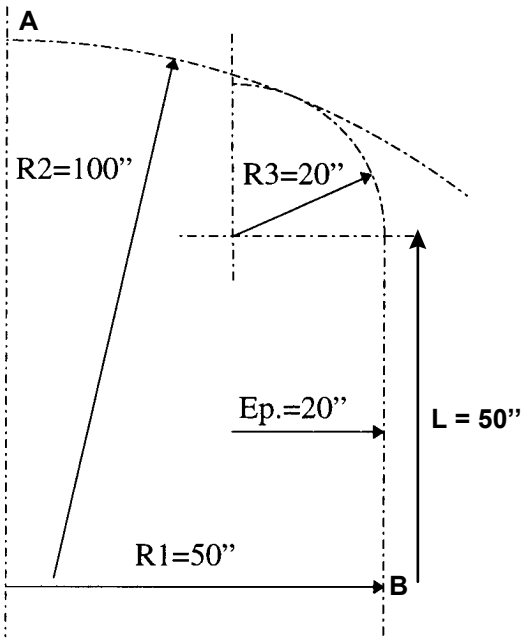
This test consists in analyzing until the ruin, the spherotoric bottom of a thick tank subjected to a pressure interns by taking of account the elastoplastic behavior of material and the nonlinear behavior of the structure.

Modeling is made with axisymmetric elements of type MEAXQU8.

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

1 Problem of reference

1.1 Geometry



1.2 Material properties

Elastoplastic material without work hardening

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

1.3 Boundary conditions and loadings

Not A : $u_x = 0$
Point B : $u_y = 0.$

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

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

The load p is applied in 50 identical increments.

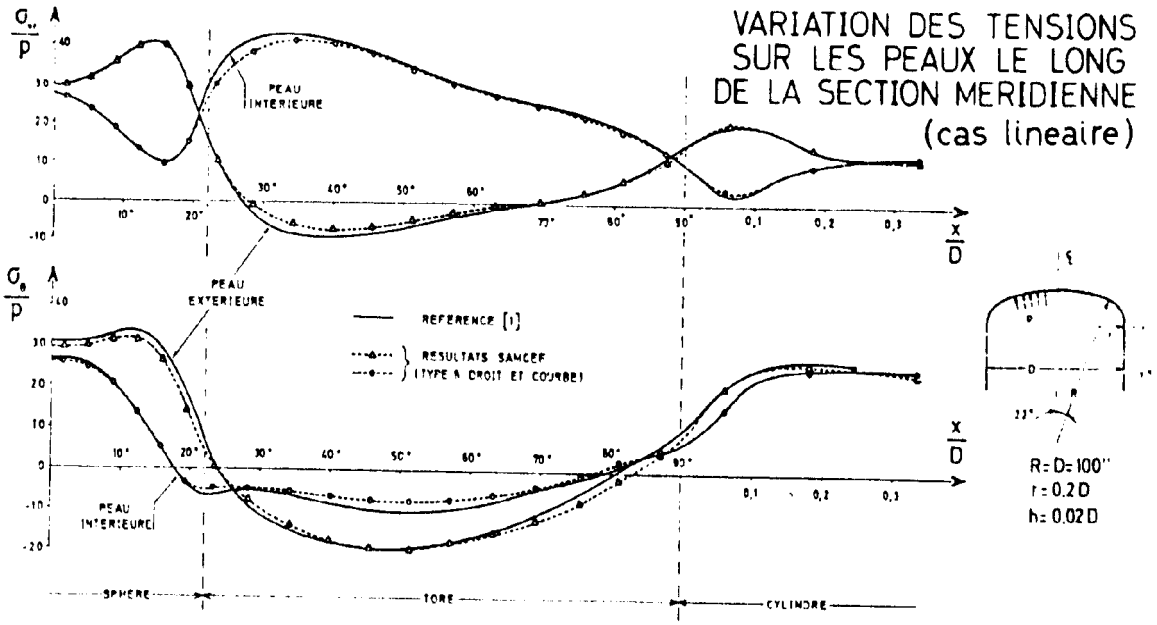
2 Reference solution

2.1 Method of calculating used for the reference solution

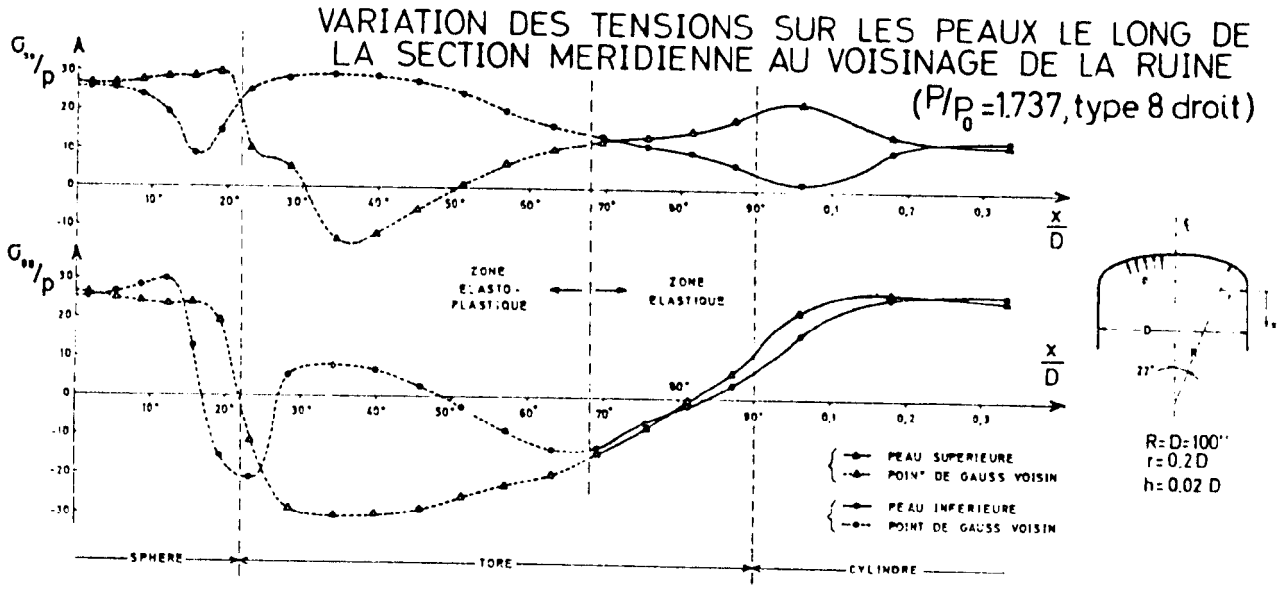
Calculation finite element with the SAMCEF software Version 7.0 (MecanI).

2.2 Reference solution

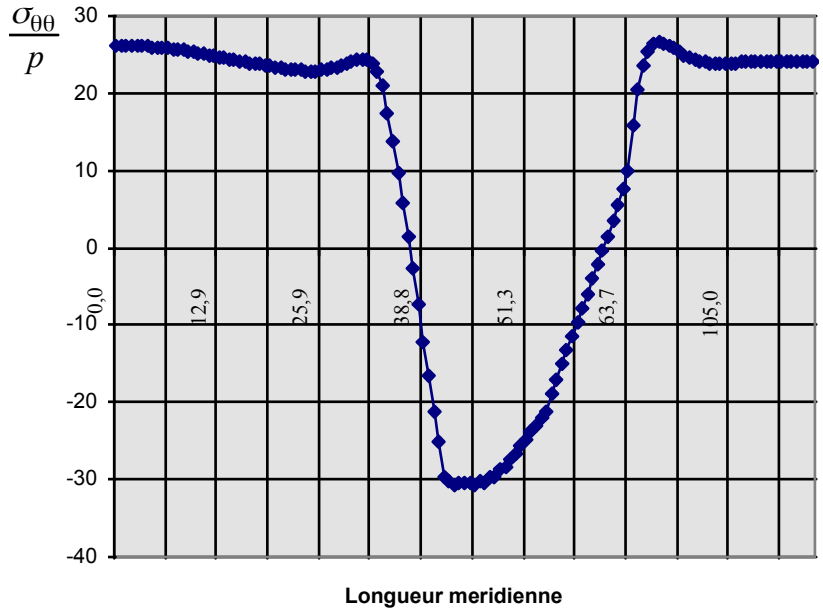
Variation of the tensions on the skins along the meridian section for an internal pressure p_0 [bib2]



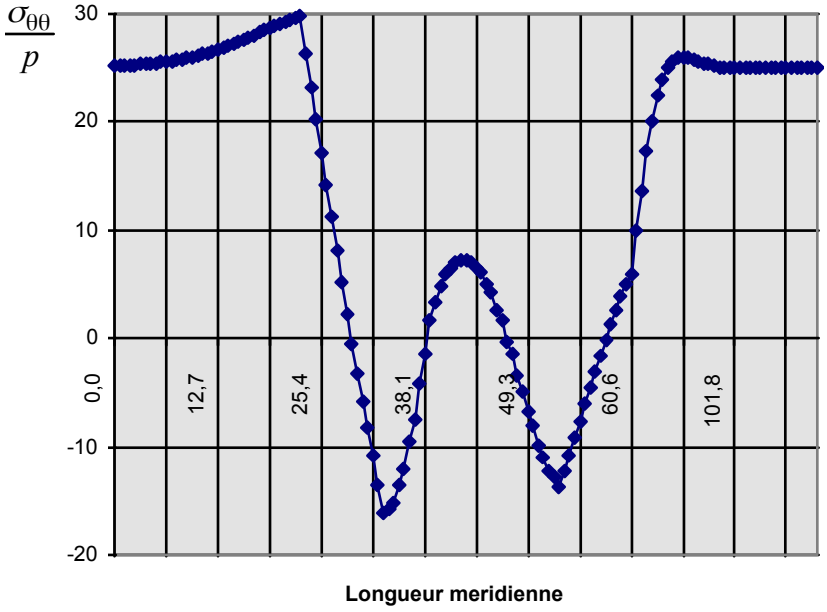
Variation of the tensions on the skins along the meridian section in the vicinity of the ruin for an internal pressure p_{max} [bib2]



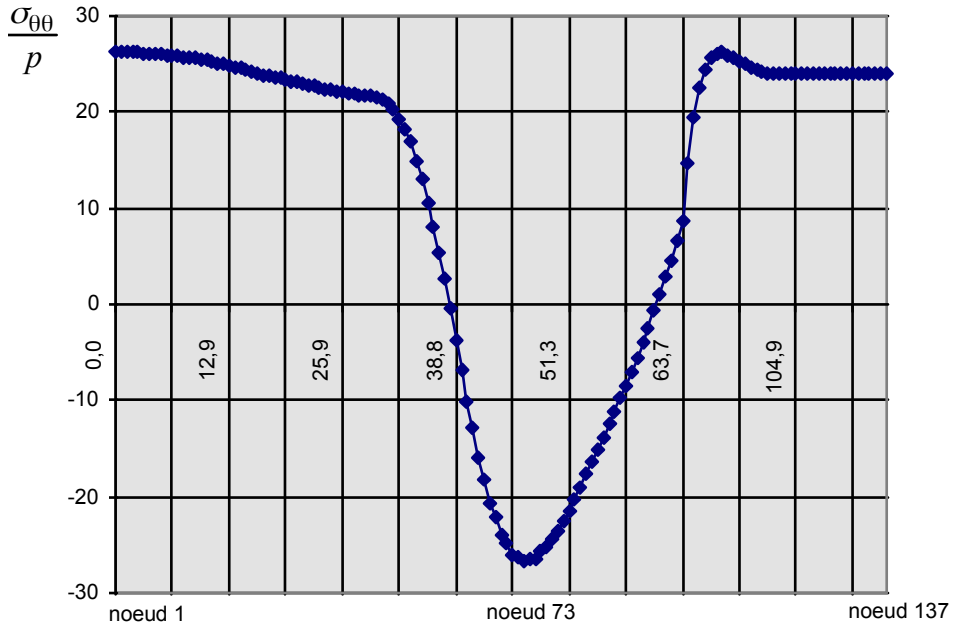
Variation of the azimuth constraint $\sigma_{\theta\theta}$ on the skin higher along the meridian section in the vicinity of the ruin for an internal pressure p_{max} . Geometrical linear calculation.



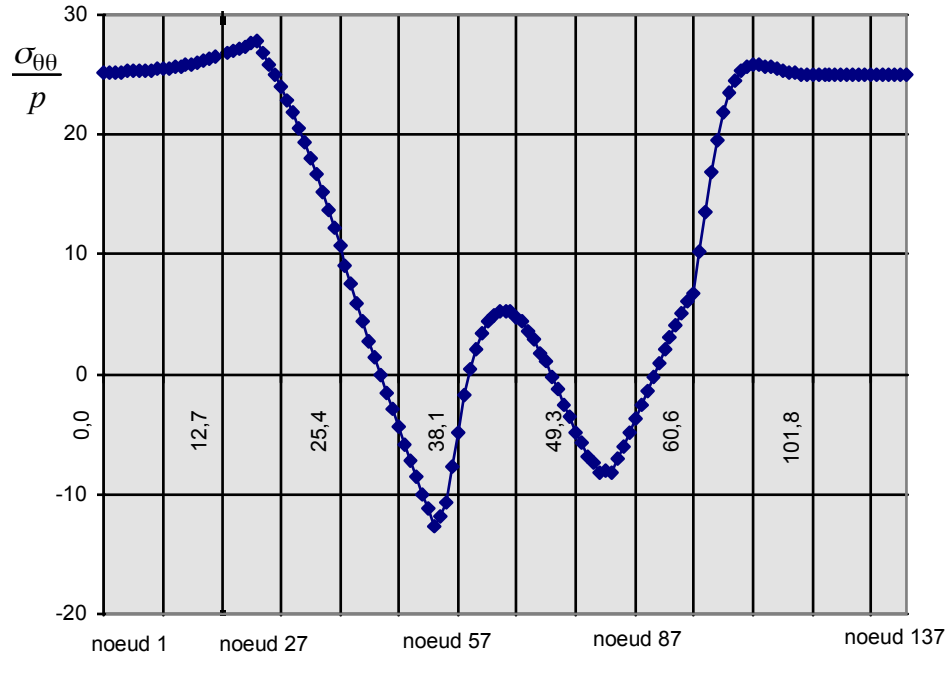
Variation of the azimuth constraint $\sigma_{\theta\theta}$ on the skin lower along the meridian section in the vicinity of the ruin for an internal pressure p_{max} . Geometrical linear calculation.

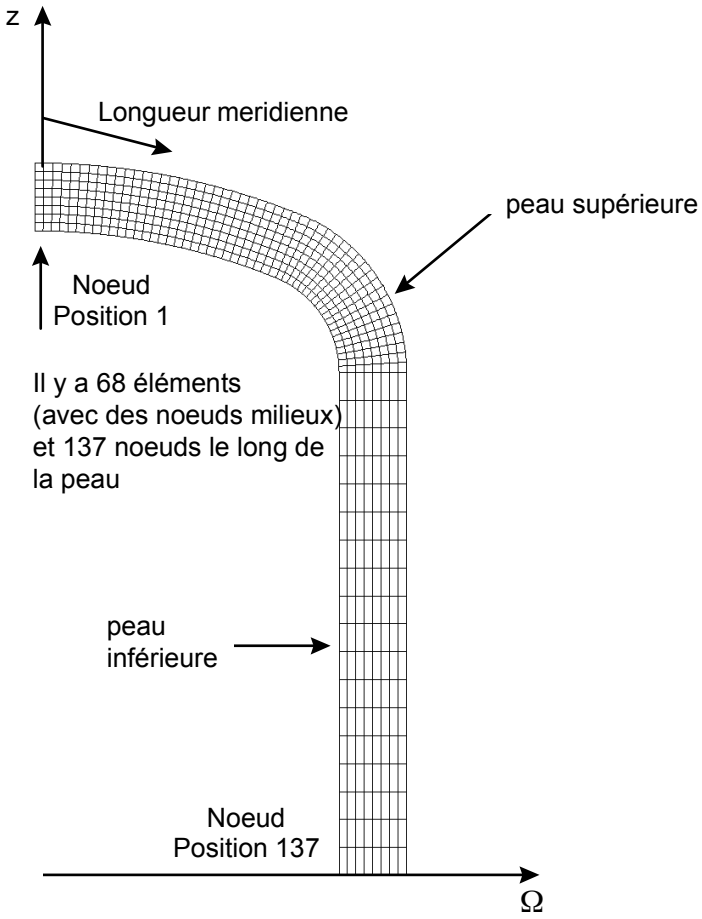


Variation of the azimuth constraint $\sigma_{\theta\theta}$ on the skin higher along the meridian section in the vicinity of the ruin for an internal pressure p_{max} . Geometrical nonlinear calculation.



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





Discretization used for the reference solution. Definition of the axes

Geometrical nonlinear calculation: $pression = p_{max}$

Skin	Meridian length $(inch)$	Position node	$\frac{\sigma_{\theta\theta}}{p}$
Higher	0.0	1	26,223
	46,298	73	– 26,688
	137.9	137	24,103
Lower	0.0	1	25,231
	16,491	27	27,909
	35,518	57	– 12,711
	52,707	87	– 8.1652
	134.76	137	25,103

Geometrical linear calculation: $pression = p_{max}$

Skin	Meridian length $(inch)$	Position node	$\frac{\sigma_{\theta\theta}}{p}$
Higher	0.0	1	26.2
	45.1	71	– 30.7
	138	137	24.0
Lower	0.0	1	25,231
	22,833	37	29,899
	32,981	53	– 16,127
	52,707	87	– 13,756
	134.76	137	25,008

Field of displacement (not A, lower skin)

Geometrical calculation…	Meridian length $(inch)$	Position node	Pressure	Displacement U^Z $(inch)$
Linear	0.0	1	$0.5\ pmax$	0.100945
	0.0	1	$pmax$	0.370468
Nonlinear	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

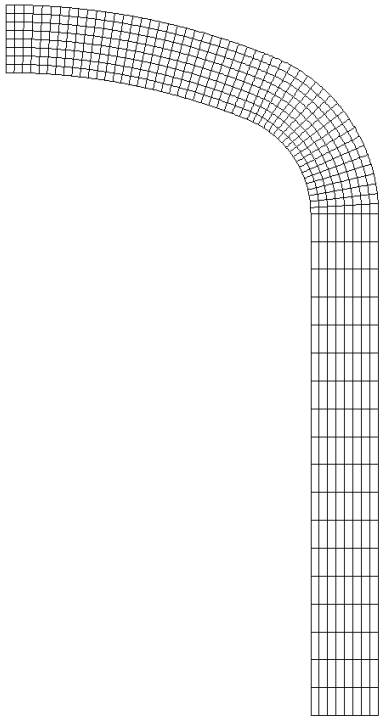
• LARSEN, P.K., POPOV, E.P., Elastic-plastic analysis of thick-walled presses vessels with sharp discontinuities, Trans. ASME Applied Mechanics, pp 1016-1019, 1971

• NYSSEN, C., Modeling by finite elements of the nonlinear behavior of aerospace structures, doctorate, University of Liege, 1979

3 Modeling A

3.1 Characteristics of modeling A

Nonlinear material + linear geometrical



3.2 Characteristics of the grid

Many nodes: 2197
Many meshs and types: 544 MEAXQU8 (diagram of integration 3 X 3) + 68 SEG3 (68 mailles sur la longueur (30 sur la partie avec un rayon de 100'', 20 sur la partie avec un rayon de 20'' et 18 sur la partie droite) et 8 sur l'épaisseur)

3.3 Sizes tested and results

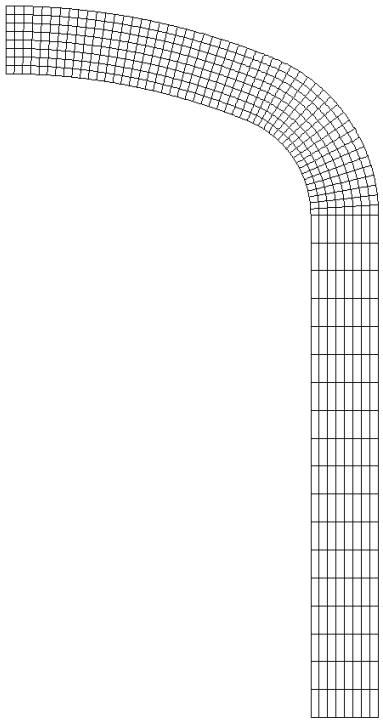
Identification	Reference	*Aster*	% difference
Long SIZZ/p Skin sup. Merid=0. p=pmax	26.2	26,218	0.071
Long SIZZ/p Skin sup. Merid=45.1 p=pmax	– 30.7	– 30,531	– 0,553
Long SIZZ/p Skin sup. Merid=138 p=pmax	24.0	24,011	– 0,553
SIZZ/p Skin inf Length. Merid=0. p=pmax	25,231	25,229	– 0,553
SIZZ/p Skin inf Length. Merid=22.833 p=pmax	29,899	29,957	– 0,553
SIZZ/p Skin inf Length. Merid=32.981 p=pmax	– 16,127	– 16,294	– 0,553
SIZZ/p Skin inf Length. Merid=52.707 p=pmax	– 13,756	– 13,699	– 0,553
SIZZ/p Skin inf Length. Merid=134.76	25,008	25,012	– 0,553

p=pmax			
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 Modeling B

4.1 Characteristics of modeling B

Nonlinear material + nonlinear geometrical



4.2 Characteristics of the grid

Many nodes: 2197
Many meshs and types: 544 MEAXQU8 (diagram of integration 3 X 3) + 68 SEG3 (68 meshs 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 Grandeurs testées et résultats

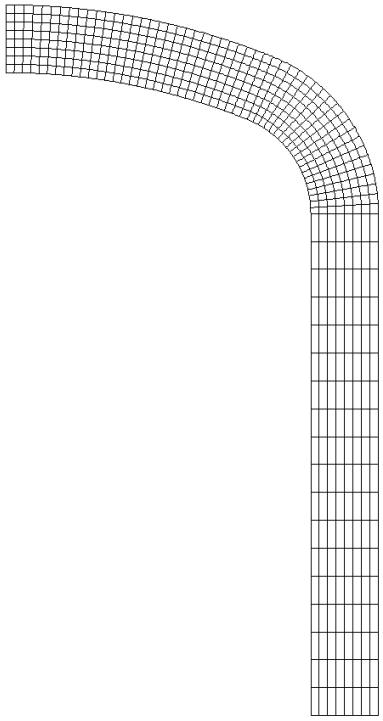
Identification	Reference	Aster	% difference
Long SIZZ/p Skin sup. Merid=0. p=pmax	26,223	26,299	0,025
Long SIZZ/p Skin sup. Merid=45.298 p=pmax	– 26,688	– 27,156	1,756
Long SIZZ/p Skin sup. Merid=137.9 p=pmax	24,103	24,018	– 0,352
SIZZ/p Skin inf Length. Merid=0. p=pmax	25,231	25,236	0,021
SIZZ/p Skin inf Length. Merid=16.491 p=pmax	27,909	28,086	0,638
SIZZ/p Skin inf Length. Merid=35.518 p=pmax	– 12,711	– 13,095	3,026
SIZZ/p Skin inf Length. Merid=52.707 p=pmax	– 8.1652	– 8,426	3,196
SIZZ/p Skin inf Length. 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 Modeling C

5.1 Characteristics of modeling C

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

A geometrical linear analysis is carried out.



5.2 Characteristics of the grid

Many nodes:	2197
Many meshs and types:	544 MEAXQU8 (diagram of integration 3 X 3) + 68 SEG3 (68 meshs 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 Sizes tested and results

Identification	Reference	Aster	% difference
Long SIZZ/p Skin sup. Merid=0. p=pmax	26.2	26,218	0,071
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SIZZ/p Skin inf Length. Merid=52.707 p=pmax	– 13,756	–13.699	– 0,553
SIZZ/p Skin inf Length. 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 modelings A and C are close to the reference (variation $< 0.6\%$). Moreover, one finds well the same results for modelings A and C; what is normal because the lower part remains elastic.

For modeling B, the variations of results enters *Code_Aster* and reference (the SAMCEF software) reach $3.3\ \%$ and come owing to the fact that nonthe geometrical linearities are treated in a different way in *Code_Aster* (by the order PETIT_REAC) and in the SAMCEF software.