

## SSNA102 - Contact multicorps elastic

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### Summary:

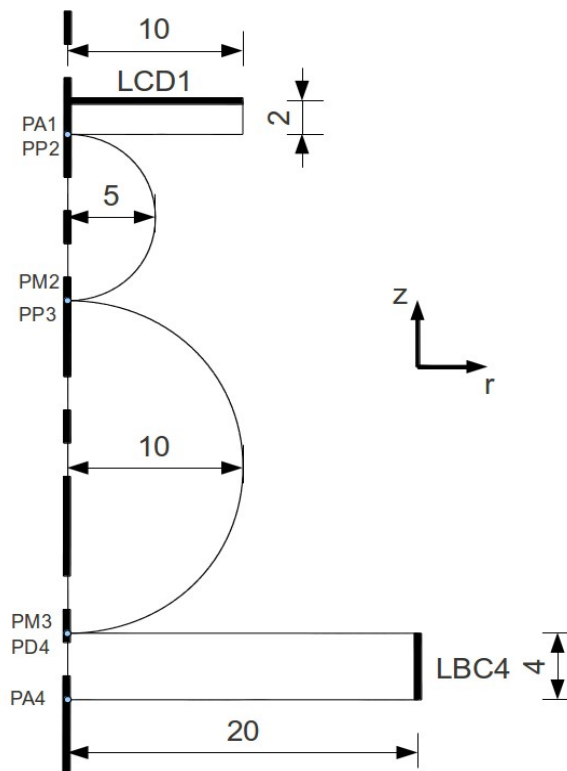
This problem of nonlinear statics of an axisymmetric structure makes it possible to test the two alternatives of the algorithm of contact in great displacements.

Calculation consists of the modeling of a structure made up of several elastic bodies in unilateral contact without friction. This calculation already was the object of a IPSI-Phi2AS CAS-test describes in note HI - 75/97/034/0. The reference solution comes from calculations carried out with codes ABAQUS, SYSTUS and the SAMCEF software.

## 1 Problem of reference

### 1.1 Geometry

Model: Axisymmetric  
Units: *mm*



### 1.2 Properties of material

Linear elastic material of characteristics:  $E = 200000.MPa$   
 $\nu = 0.3$

### 1.3 Boundary conditions and loadings

- $DR$  and  $DZ$  blocked on  $LBC4$
- $DZ$  imposed  $-2.0mm$  on  $LCD1$
- Connections between degrees of freedom:  
 $DZ(PA1) = DZ(PP2)$   
 $DZ(PM3) = DZ(PD4)$
- The first calculation: conditions of unilateral contact between each face of the solids in opposite, is 3 couples of paired surfaces
- The second calculation (modeling A only): conditions of unilateral contact between each face of the solids in opposite, except that the top in mode `RESOLUTION='NON'` (test of the mode without calculation in multi-zones)

## 2 Reference solution

### 2.1 Method of calculating used for the reference solution

Average of the results got by various computer codes in mechanics, ABAQUS, SYSTUS, the SAMCEF software, within the framework of a case test IPSI-  $\Phi_2$  ACE [bib1].

### 2.2 Results of reference

Vertical displacement of the point  $PA4$  :

ABAQUS	-0,83 mm	
SYSTUS	-0,82 mm	That is to say an average of -0,81 mm
The SAMCEF software	-0,78 mm	

Vertical component of the reaction to embedding  $LBC4$  :

ABAQUS	110270 N	
SYSTUS	109500 N	That is to say an average of 108257 N
The SAMCEF software	105000 N	

**NB:**

*The efforts calculated by Aster into axisymmetric are it by radian. The value to be obtained is thus  $108257/2\pi = 17229.58 N / rd$*

### 2.3 Uncertainties on the solution

Dispersion around the median value of vertical displacement in  $PA4$  is of 4%. Dispersion around the vertical reaction to embedding is of 3%.

### 2.4 Bibliographical references

1. I. VAUTIER: "Example of use of the features of contact in great displacements in *Code\_Aster*", HI-75/97/034/0 notes.

## 3 Modeling A

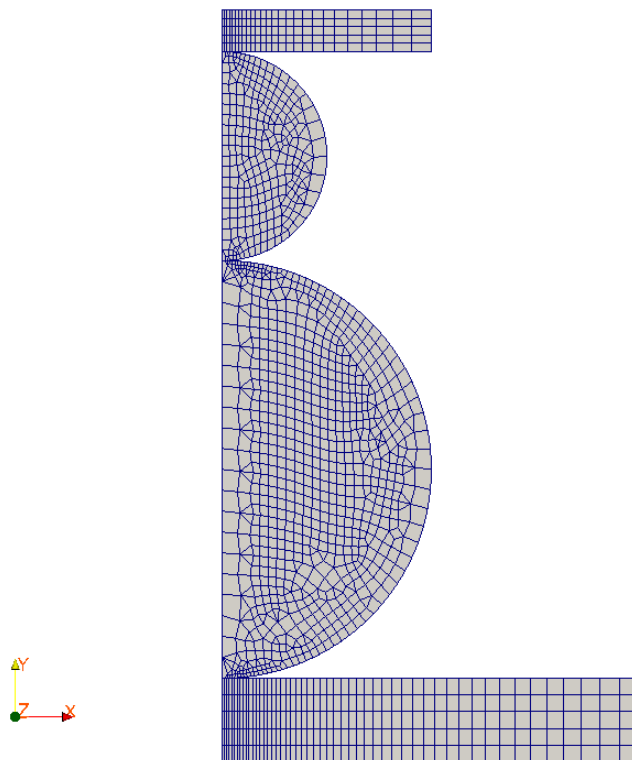
### 3.1 Characteristics of modeling

Modeling is `AXIS`, two calculations are carried out: the first to calculate the reference solution, the second to validate the contact without resolution (calculation of the games only). The algorithm of contact used is that by default.

### 3.2 Characteristics of the grid

Nodes: 4610

Meshs: 1348 QUAD8, 114 TRIA6



### 3.3 Sizes tested and results

The first calculation

Identification	Type of reference	Value of reference	Tolerance
<i>DY</i> at the point <i>PA4</i>	'SOURCE_EXTERNE'	-0.81 mm	4,0%
<i>DY</i> at the point <i>PA4</i>	'NON_REGRESSION'	-0.84 mm	1,0E- 8%
<i>FY</i> on the edge <i>LBC4</i>	'SOURCE_EXTERNE'	17229.58 N	1,6%
<i>FY</i> on the edge <i>LBC4</i>	'NON_REGRESSION'	17496.59 N	1,0E- 8%

The second calculation

Identification	Type of reference	Value of reference	Tolerance
Minimum clearance upper surface	'NON_REGRESSION'	-1.749 mm	1,0E- 6%
Maximum clearance upper surface	'NON_REGRESSION'	3.28 mm	1,0E- 6%



## 4 Modeling B

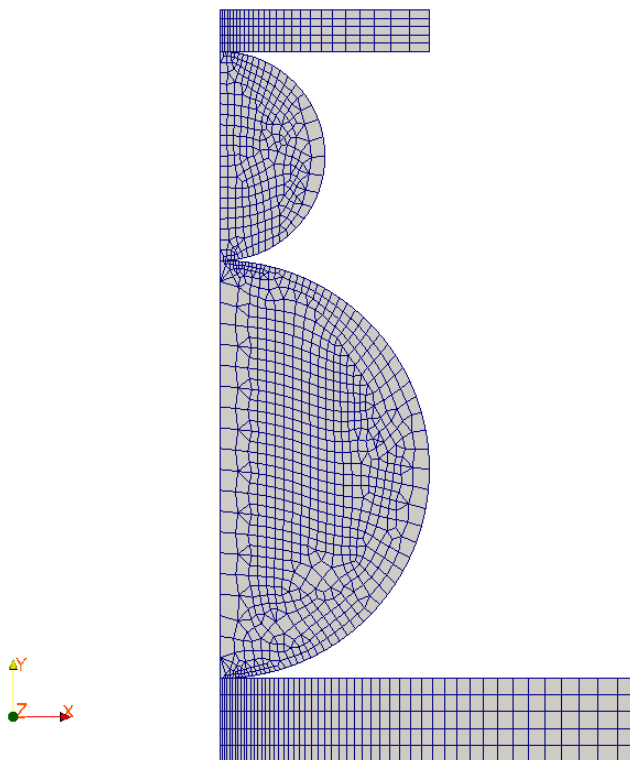
### 4.1 Characteristics of modeling

Modeling is `AXIS`. The algorithm of contact used is `'LAGRANGIAN'`.

### 4.2 Characteristics of the grid

Nodes: 4610

Meshs: 1348 QUAD8, 114 TRIA6



### 4.3 Sizes tested and results

Identification	Type of reference	Value of reference	Tolerance
<i>DY</i> at the point <i>PA4</i>	<code>'SOURCE_EXTERNE'</code>	-0.81 <i>mm</i>	4,0%
<i>DY</i> at the point <i>PA4</i>	<code>'NON_REGRESSION'</code>	-0.84 <i>mm</i>	1,0E- 8%
<i>FY</i> on the edge <i>LBC4</i>	<code>'SOURCE_EXTERNE'</code>	17229.58 <i>N</i>	1,6%
<i>FY</i> on the edge <i>LBC4</i>	<code>'NON_REGRESSION'</code>	17503.14 <i>N</i>	1,0E- 8%

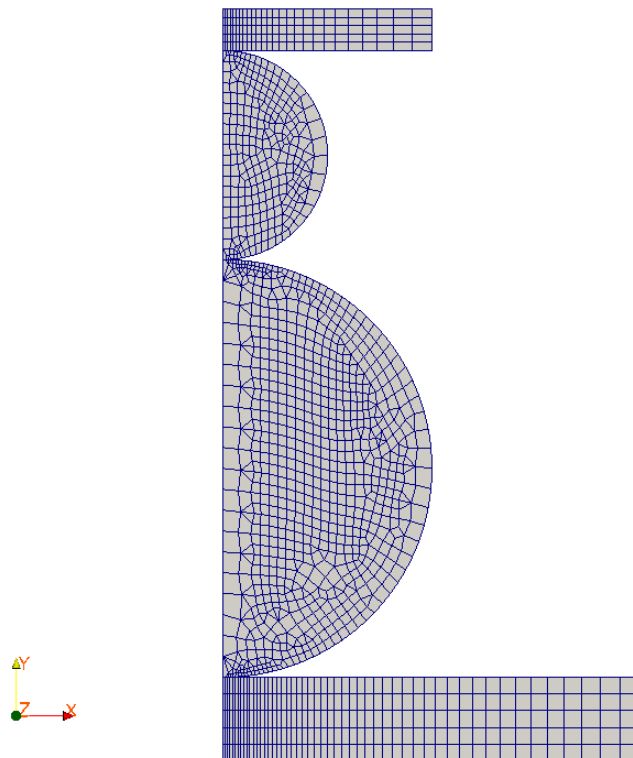
## 5 Modeling C

### 5.1 Characteristics of modeling

Modeling is `AXIS`. The algorithm of contact used is `'LAGRANGIAN'`, the normal used is an average of the normals Master and slave.

### 5.2 Characteristics of the grid

Nodes: 4610  
Meshes: 1348 QUAD8, 114 TRIA6



### 5.3 Sizes tested and results

Identification	Type of reference	Value of reference	Tolerance
<i>DY</i> at the point <i>PA4</i>	<code>'SOURCE_EXTERNE'</code>	-0.81 mm	4,0%
<i>DY</i> at the point <i>PA4</i>	<code>'NON_REGRESSION'</code>	-0.84 mm	1,0E- 8%
<i>FY</i> on the edge <i>LBC4</i>	<code>'SOURCE_EXTERNE'</code>	17229.58 N	1,6%
<i>FY</i> on the edge <i>LBC4</i>	<code>'NON_REGRESSION'</code>	17502.68 N	1,0E- 8%

## 6 Modeling D

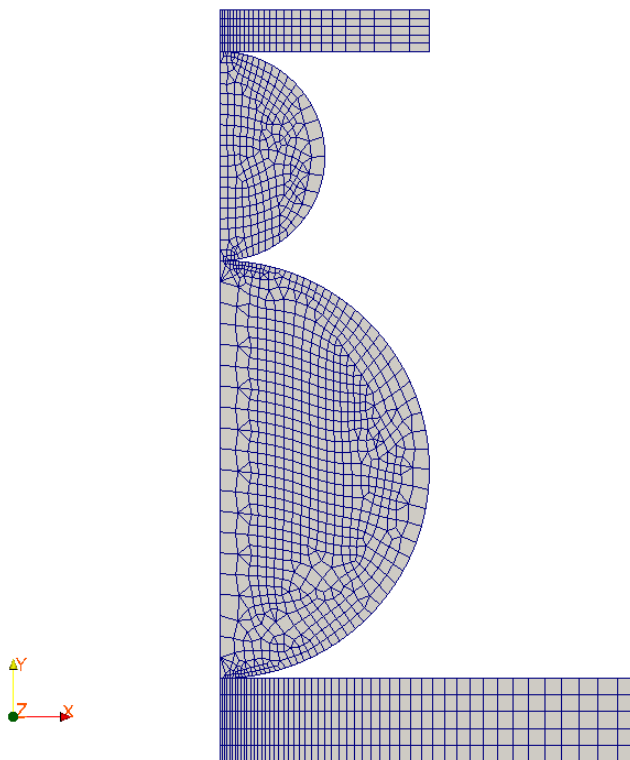
### 6.1 Characteristics of modeling

Modeling is `AXIS`. The formulation of contact used is `'CONTINUES'`.

### 6.2 Characteristics of the grid

Nodes: 4610

Meshes: 1348 QUAD8, 114 TRIA6



### 6.3 Sizes tested and results

Identification	Type of reference	Value of reference	Tolerance
<i>DY</i> at the point <i>PA4</i>	<code>'SOURCE_EXTERNE'</code>	-0.81 mm	4,0%
<i>DY</i> at the point <i>PA4</i>	<code>'NON_REGRESSION'</code>	-0.841371811 mm	1,0E- 8%
<i>FY</i> on the edge <i>LBC4</i>	<code>'SOURCE_EXTERNE'</code>	17229.58 N	1,6%
<i>FY</i> on the edge <i>LBC4</i>	<code>'NON_REGRESSION'</code>	17501.437425187 N	1,0E- 8%



## 7 Modeling E

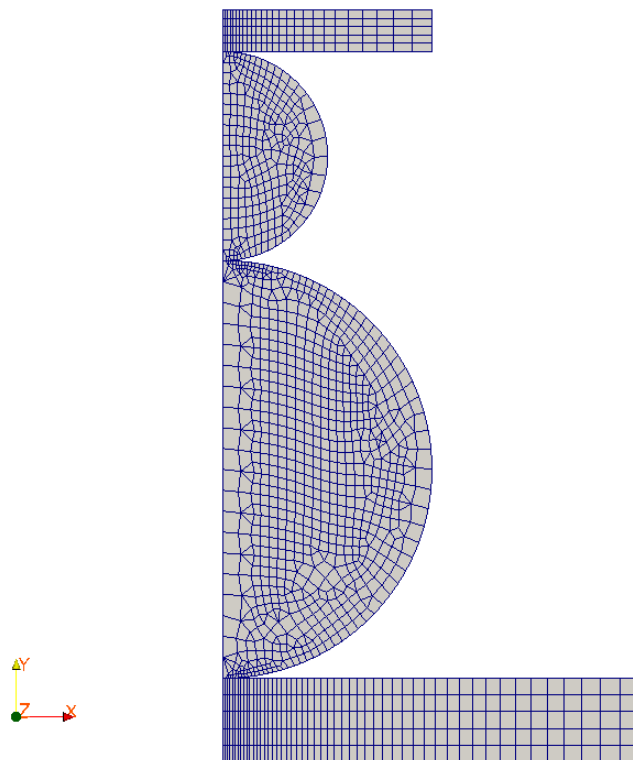
### 7.1 Characteristics of modeling

Modeling is `AXIS`. The algorithm of contact used is `'GCP'`.

### 7.2 Characteristics of the grid

Nodes: 4610

Meshs: 1348 `QUAD8`, 114 `TRIA6`



### 7.3 Sizes tested and results

Identification	Type of reference	Value of reference	Tolerance
<i>DY</i> at the point <i>PA4</i>	<code>'SOURCE_EXTERNE'</code>	-0.81 <i>mm</i>	4,0%
<i>DY</i> at the point <i>PA4</i>	<code>'NON_REGRESSION'</code>	-0.84 <i>mm</i>	0,1%
<i>FY</i> on the edge <i>LBC4</i>	<code>'SOURCE_EXTERNE'</code>	17229.58 <i>N</i>	1,6%
<i>FY</i> on the edge <i>LBC4</i>	<code>'NON_REGRESSION'</code>	17496.59 <i>N</i>	0,1%

### 7.4 Remarks

With the convergence criteria of the gradient combined project (selected sufficiently small), one obtains the same solution exactly as that of modeling A (algorithm `'CONSTRAINT'`).

## 8 Modeling F

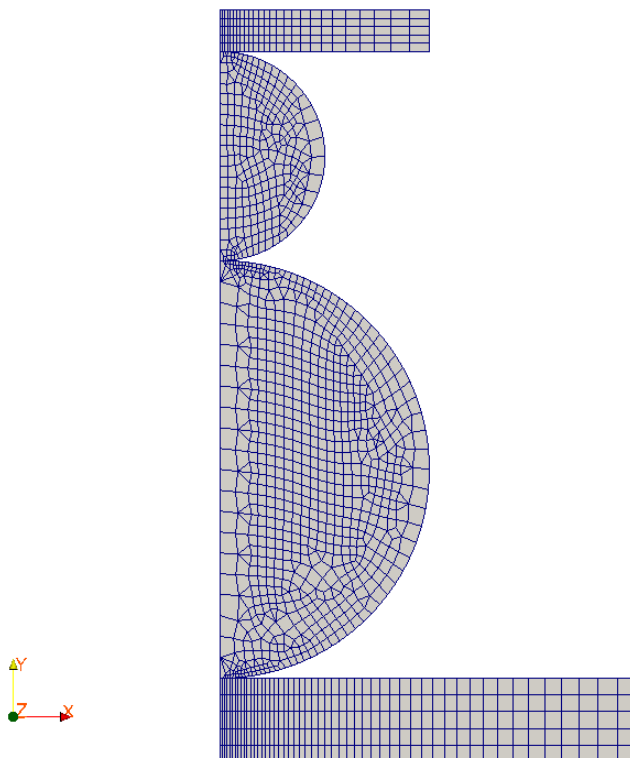
### 8.1 Characteristics of modeling

Modeling is `AXIS`. The formulation of contact used is `'CONTINUES'`. In this modeling, friction is added on the zone of contact of the medium with a coefficient of friction very weak in order to validate the mixture of zone with contact alone and friction.

### 8.2 Characteristics of the grid

Nodes: 4610

Meshs: 1348 QUAD8, 114 TRIA6



### 8.3 Sizes tested and results

Identification	Type of reference	Value of reference	Tolerance
<i>DY</i> at the point <i>PA4</i>	<code>'SOURCE_EXTERNE'</code>	-0.81 <i>mm</i>	4,0%
<i>DY</i> at the point <i>PA4</i>	<code>'NON_REGRESSION'</code>	-0.84 <i>mm</i>	0,1%
<i>FY</i> on the edge <i>LBC4</i>	<code>'SOURCE_EXTERNE'</code>	17229.58 <i>N</i>	3,0%
<i>FY</i> on the edge <i>LBC4</i>	<code>'NON_REGRESSION'</code>	17496.15 <i>N</i>	0,1%

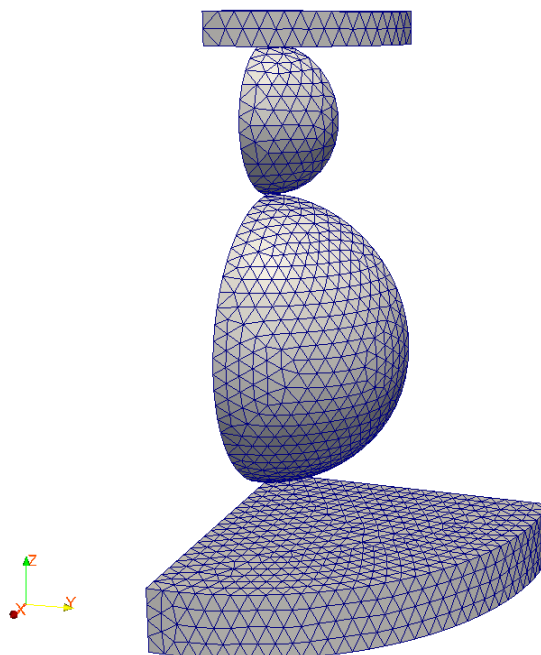
## 9 Modeling G

### 9.1 Characteristics of modeling

Modeling is 3D. The formulation of contact used is 'CONTINUES'.

### 9.2 Characteristics of the grid

Nodes: 4465  
Meshs: 19389 TETRA4



### 9.3 Sizes tested and results

Identification	Type of reference	Value of reference	Tolerance
<i>DZ</i> at the point <i>PA4</i>	'SOURCE_EXTERNE'	-0.81 <i>mm</i>	4,0%
<i>DZ</i> at the point <i>PA4</i>	'NON_REGRESSION'	-0.80 <i>mm</i>	1,0E- 10%
<i>FZ</i> on the edge <i>ENCAST</i>	'SOURCE_EXTERNE'	27064.25 <i>N</i>	5,0%
<i>FZ</i> on the edge <i>ENCAST</i>	'NON_REGRESSION'	28329.08 <i>N</i>	1,0E- 10%

## 10 Summary of the results

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The results are satisfactory taking into account the diversity of the origin of the reference solution. The various algorithms of contact give identical results in displacement and force.