

## SSNV504 - Extrusion of a Summarized

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### piece:

This test simulates the extrusion (without friction) of a piece, case frequently encountered in the industrial studies of working. The interest of this test is mainly to validate the “transition” of geometrical singularities (acute angles and blunt) and to test the taking into account of two contact zones (contact multi-zones).

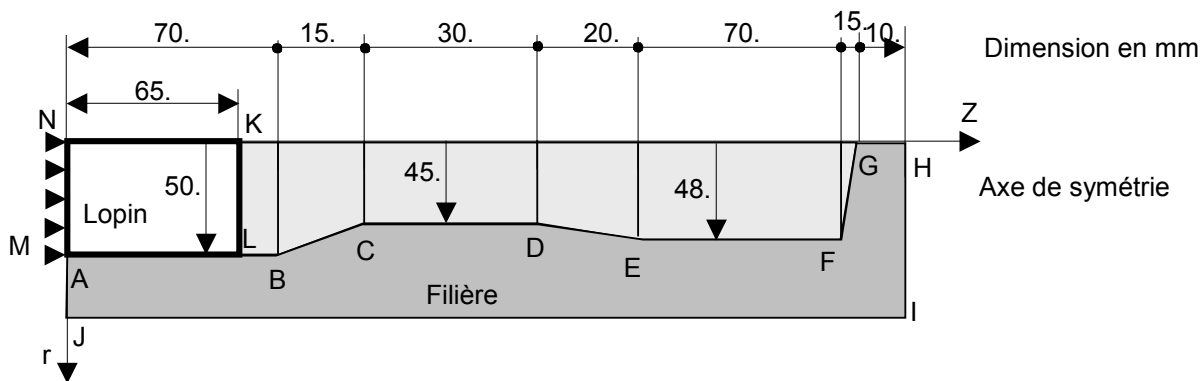
The modelizations selected are the following ones:

- Modelization A (AXIS): CONTACT node nets, associated with meshes SEG2,
- Modelization B (3D): CONTACT node nets, associated with meshes QUAD4,
- Modelization C (AXIS): CONTACT node nets SLIDE, associated with meshes SEG2,
- Modelization D (AXIS): CONTACT, continuous method associated with meshes SEG2,
- Modelization E (AXIS): CONTACT node nets SLIDE, associated with meshes SEG3,
- Modelization F (3D): CONTACT node nets SLIDE, associated with meshes QUAD4,
- Modelization G (3D): CONTACT node nets SLIDE, associated with meshes QUAD8,
- Modelization H (2D): CONTACT, continuous method associated with SEG3,
- Modelization I (AXIS): CONTACT SLIDE, continuous method associated with SEG3,
- Modelization J (AXIS): CONTACT SLIDE, continuous method associated with QUAD4

the modelizations with SLIDE make it possible to maintain the contact throughout extrusion, in a mathematical way. Result is physically close to the modelization without slide, since it is about an extrusion without friction.

## 1 Problem of reference

### 1.1 Geometry



### 1.2 Properties of the material

Piece:

- $E = 5000. MPa$  Modulus Young
- $\nu = 0.45$  Poisson's ratio

Sector:

- $E = 200\ 000. MPa$  Modulus
- $\nu = 0.3$  Piece Young Poisson's ratio

/sector

- $\mu = 0$  Coefficient of kinetic friction

### 1.3 Boundary conditions and loadings

Boundary conditions: lines  $HI$ ,  $IJ$  and  $JA$  clamped

Loading: Control in displacement imposed on the back face of the piece

### 1.4 Initial conditions

Without object.

## 2 Reference solution

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

the purpose of this benchmark is to analyze the feasibility of computation into axisymmetric and in 3D

### 2.2 Results of reference

No value of reference is available. The values of reference which will be retained to test the future versions of *Code\_Aster* are those obtained during the first execution with the modelization A and which will be considered to be acceptable. The analyzed values of reference are displacements of the face before piece.

Piece (localization)	Displacement ( mm )	Comments
<i>K</i>	5.000	Piece in the vicinity of the point <i>B</i> of sector
<i>K</i>	20.825	Piece in the vicinity of the point <i>C</i> of sector
<i>K</i>	55.880	Piece in the vicinity of the point <i>D</i> of sector
<i>K</i>	78.690	Piece in the vicinity of the point <i>E</i> of sector
<i>K</i>	144.895	Piece in the vicinity of the point <i>F</i> of sector
<i>K</i>	155.096	Piece at the point <i>G</i> of the sector

For computation with checking of the contact without computation (option RESOLUTION=' NON '), one tests the displacement of the face before piece and interpenetration of the surfaces.

Piece (localization)	Displacement ( mm )	Comments
<i>K</i>	155.096	Piece at the point <i>G</i> of the sector

Piece (localization)	Interpenetration ( mm )	Urgent
<i>L</i>	-5.0	100.0
<i>L</i>	-2.0	155.0

### 2.3 Uncertainties on the solution

Lower than 0.1%

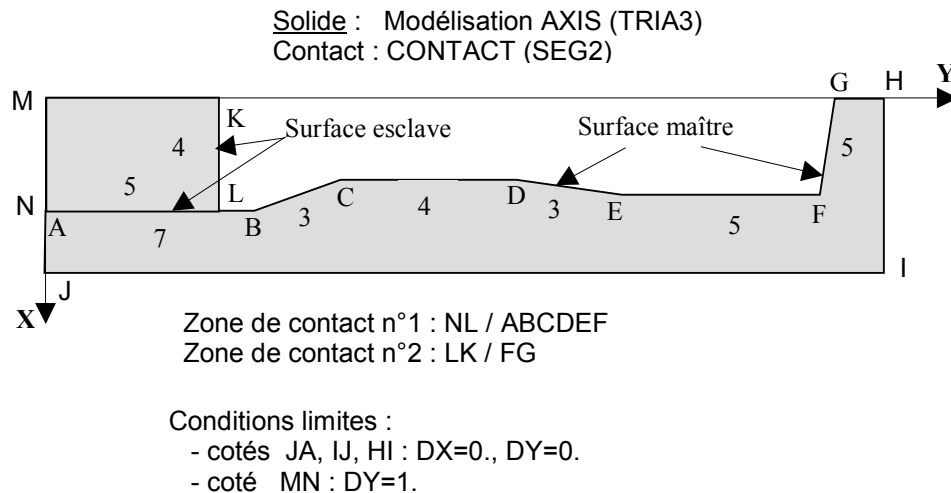
### 2.4 bibliographical References

No

## 3 Modelization A

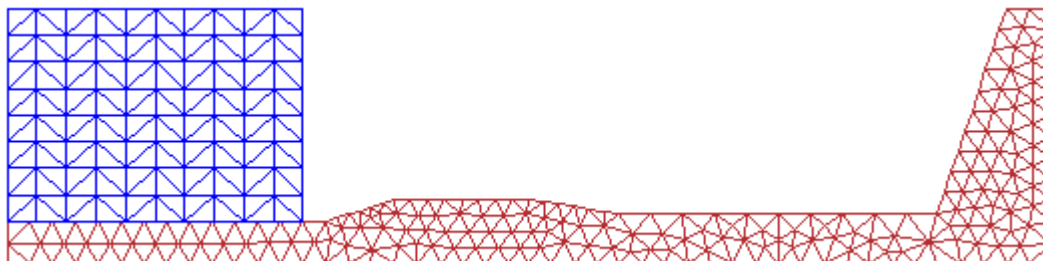
### 3.1 Characteristic of the modelization

One uses a modelization `AXIS` (linear elements).



The discrete formulation of the contact is used (method of the active stresses).

### 3.2 Characteristics of the mesh



Many nodes: 333  
Number of meshes: 510 `TRIA3` and 152 `SEG2`  
Many nodes in contact: 20

### 3.3 Quantities tested and results

One compared to the tests the following  $Y$  displacement of  $K$  the point of the piece surface  $ABCDEFG$  of the sector.

Standard	identification of reference	Value of reference	Tolerance
Not $K$ /Not $B - DY$	"ANALYTIQUE"	5.0000	0.1%
Point $K$ /Not $C - DY$	"ANALYTIQUE"	20.8250	0.1%
Point $K$ /Not $D - DY$	"ANALYTIQUE"	55.8800	0.2%

Point <i>K</i> /Not <i>E</i> - <i>DY</i>	"ANALYTIQUE"	78.6900	0.1%
Point <i>K</i> /Not <i>F</i> - <i>DY</i>	"ANALYTIQUE"	144.8950	0.1%
Point <i>K</i> /Not <i>G</i> - <i>DY</i>	"ANALYTIQUE"	155.0960	0.1%

Checking of mode RESOLUTION=' NON' :

Standard	identification of reference	Value of reference	Tolerance
Not <i>K</i> /Not <i>G</i> - <i>DY</i>	"ANALYTIQUE"	155.0960	0.1%
Clearance <i>LC</i>	"ANALYTIQUE"	-5.0000	0.1%
Clearance <i>LE</i>	"ANALYTIQUE"	-2.0000	0.1%

## 3.4 Remarks

The computation are carried out by imposing a displacement on the back face of the piece (MN) . Displacement is imposed in the following way:

- of 0.mm with 5.mm in 5 steps
- of 5.mm with 20.mm in 5 steps
- of 20.mm with 50.mm in 5 steps
- of 50.mm with 70.mm in 5 steps
- of 70.mm with 140.mm in 5 steps
- of 140.mm with 155.mm in 5 steps  
with

computations do not converge with the key keys by default used for convergence in STAT\_NON\_LINE, because the default value of RESI\_GLOB\_RELA = 1.E-6 is too constraining (forces to which the piece is subjected being at the beginning relatively weak). To mitigate this problem, it is necessary to use the key word RESI\_GLOB\_MAXI = 1.E-6.

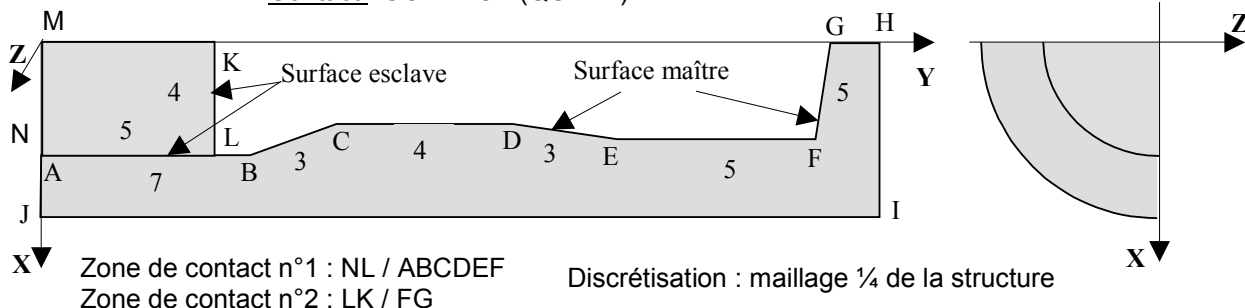
## 4 Modelization B

### 4.1 Characteristic of the modelization

One uses a modelization 3D (linear elements).

Solide : Modélisation 3D (HEXA8, PENTA6)

Contact : CONTACT (QUAD4)

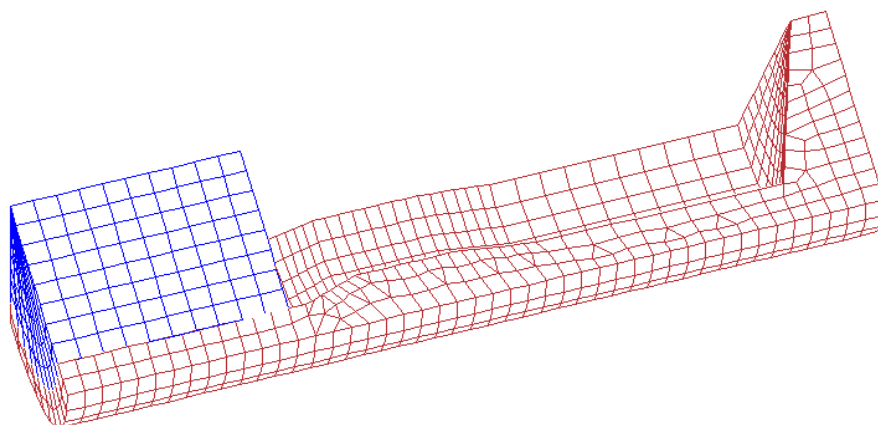


Conditions aux limites sur les groupes de nœuds suivants :

- 'FIL\_EXT' : groupe des nœuds situés sur la surface extérieure de la filière (HI, IJ, JA)  
=> DX=0., DY =0., DZ=0.
- 'FIL\_SYM1' : Groupe des nœuds de la filière situés dans le plan XOY : DZ=0.
- 'FIL\_SYM2' : Groupe des nœuds de la filière situés dans le plan YOZ : DX=0.
- 'LOP\_SYM1' : Groupe des nœuds du lopin situés dans le plan XOY : DZ=0.
- 'LOP\_SYM2' : Groupe des nœuds du lopin situés dans le plan YOZ : DX=0
- 'LOP\_DDL' : Groupe des nœuds situés sur la face arrière du lopin : DY =1

The discrete formulation of the contact is used (method of the active stresses).

### 4.2 Characteristics of the mesh



Many nodes: 3292

Number of meshes: 2150 HEXA8, 260 PENTA6, 1814 QUAD4 and 68 TRIA3

Many nodes in contact: 210

### 4.3 Quantities tested and results

One compared to the tests the following  $Y$  displacement of  $K$  the point of the piece surface  $ABCDEFG$  of the sector.

Standard	identification of reference	Value of reference	Tolerance
Not $K$ /Not $B - DY$	"ANALYTIQUE"	5.0000	0.1%
Point $K$ /Not $C - DY$	"ANALYTIQUE"	20.8250	1.0%
Point $K$ /Not $D - DY$	"ANALYTIQUE"	55.8800	1.0%
Point $K$ /Not $E - DY$	"ANALYTIQUE"	78.6900	1.0%
Point $K$ /Not $F - DY$	"ANALYTIQUE"	144.8950	1.0%
Point $K$ /Not $G - DY$	"ANALYTIQUE"	155.0960	1.0%

One tests the nombre of iterations of Newton when the point  $K$  of the piece is opposite the points  $B$   $C$   $D$   $E$ ,  $F$  and  $G$  of the sector.

Standard	identification of reference	Value of reference	Tolerance
ITER_GLOB /Not $B$	"NON_REGRESSION"	2	0.00%
ITER_GLOB /Not $C$	"NON_REGRESSION"	2	0.00%
ITER_GLOB /Not $D$	"NON_REGRESSION"	2	0.00%
ITER_GLOB /Not $E$	"NON_REGRESSION"	2	0.00%
ITER_GLOB /Not $F$	"NON_REGRESSION"	2	0.00%
ITER_GLOB /Not $G$	"NON_REGRESSION"	2	0.00%

## 4.4 Remarks

- The computation is carried out by imposing a displacement on the back face of the piece (MN) . Displacement is imposed in the following way:
  - of 0.mm with 5.mm in 5 steps
  - of 5.mm with 15.mm in 10 steps
  - of 5.mm with 20.mm in 5 steps
  - of 20.mm 50.mm in 5 steps  
with
  - of 50.mm 70.mm in 10 steps  
with
  - of 70.mm 140.mm in 35 steps  
with
  - of 140.mm 155.mm in 15 step  
with
- computations do not converge with the key keys by default used for convergence in STAT\_NON\_LINE, because the default value of RESI\_GLOB\_RELA = 1.E-6 is too constraining (forces to which the piece is subjected being at the beginning relatively weak). To mitigate this problem, it is necessary to use the key word RESI\_GLOB\_MAXI = 1.E-6.

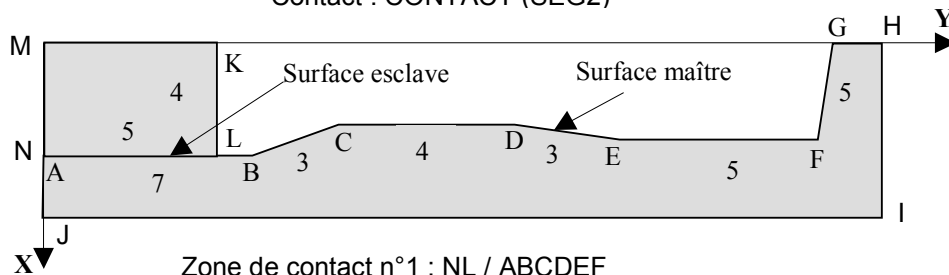
## 5 Modelization C

### 5.1 Characteristic of the modelization

One uses a modelization `AXIS` (linear elements).

`Solide` : Modélisation `AXIS` (`TRIA3`)

`Contact` : `CONTACT` (`SEG2`)



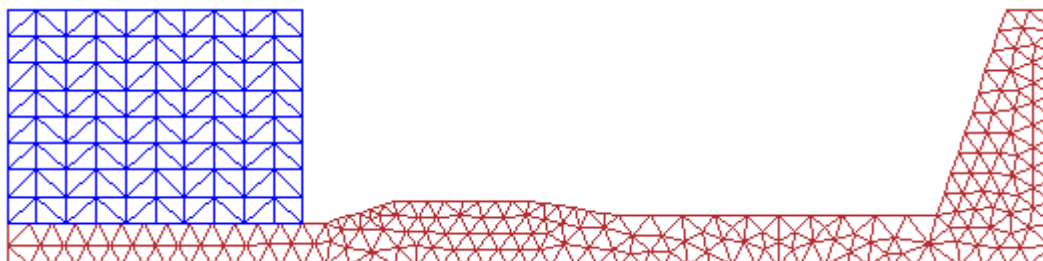
Conditions limites :

- cotés JA, IJ, HI :  $DX=0.$ ,  $DY=0.$
- coté MN :  $DY=1.$

The discrete formulation of the contact is used (method of the active stresses).

One uses here the function `SLIDE` which makes it possible to maintain the contact throughout extrusion, in a mathematical way. Result is physically close to the modelization without slide, since it is about an extrusion without friction.

### 5.2 Characteristics of the mesh



Many nodes: 333

Number of meshes: 510 `TRIA3` and 152 `SEG2`

Many nodes in contact: 20

### 5.3 Quantities tested and results

One compared to the tests the following  $Y$  displacement of  $K$  the point of the piece surface  $ABCDEFG$  of the sector.

Standard	identification of reference	Value of reference	Tolerance
Not $K$ /Not $B - DY$	"ANALYTIQUE"	5.0000	0.1%
Point $K$ /Not $F - DY$	"NON_REGRESSION"	144.2240	0.1%

### 5.4 Remarks

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.



The computation is carried out by imposing a displacement on the back face of the piece (MN) .  
Displacement is imposed in the following way:

- of 0.mm with 5.mm in 5 steps
- of 5.mm with 20.mm in 5 steps
- of 20.mm 50.mm in 5 steps  
with
- of 50.mm 70.mm in 5 steps  
with
- of 70.mm 140.mm in 5 steps  
with

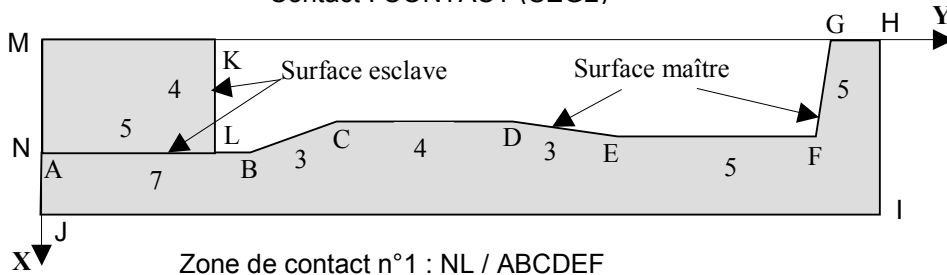
computations do not converge with the key keys by default used for convergence in `STAT_NON_LINE`, because the default value of `RESI_GLOB_RELA = 1.E-6` is too constraining (forces to which the piece is subjected being at the beginning relatively weak). To mitigate this problem, it is necessary to use the key word `RESI_GLOB_MAXI = 1.E-6`.

## 6 Modelization D

### 6.1 Characteristic of the modelization

One uses a modelization `AXIS` (linear elements).

Solide : Modélisation `AXIS` (`TRIA3`)  
Contact : `CONTACT` (`SEG2`)

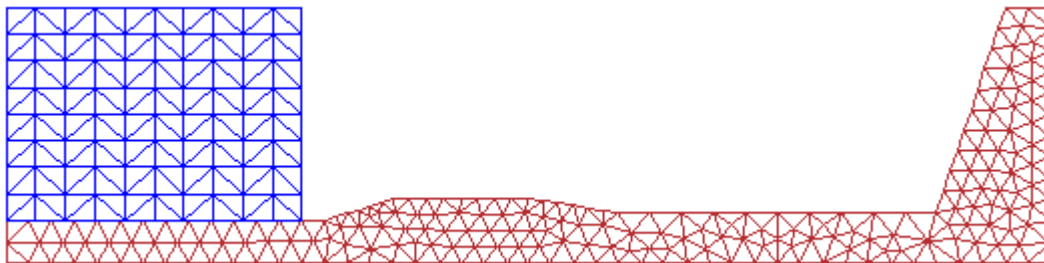


Zone de contact n°1 : NL / ABCDEF  
Zone de contact n°2 : LK / FG

Conditions limites :  
- cotés JA, IJ, HI :  $DX=0.$ ,  $DY=0.$   
- coté MN :  $DY=1.$

One uses the formulation continues of the contact.

### 6.2 Characteristics of the mesh



Many nodes: 333  
Number of meshes: 510 `TRIA3` and 152 `SEG2`  
Many nodes in contact: 20

### 6.3 Quantities tested and results

One compared to the tests the following  $Y$  displacement of  $K$  the point of the piece surface  $ABCDEFGH$  of the sector.

Standard	identification of reference	Value of reference	Tolerance
Not $K$ /Not $B$ - $DY$	"ANALYTIQUE"	5.0000	0.1%
Point $K$ /Not $C$ - $DY$	"ANALYTIQUE"	20.8250	0.2%
Point $K$ /Not $D$ - $DY$	"ANALYTIQUE"	55.8800	0.2%
Point $K$ /Not $E$ - $DY$	"ANALYTIQUE"	78.6900	0.1%

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

Point $K$ /Not $F - DY$	"ANALYTIQUE"	144.8950	0.1%
Point $K$ /Not $G - DY$	"ANALYTIQUE"	155.0960	0.1%

One tests the nombre of iterations of Newton when the point  $K$  of the piece is opposite the points  $B$   $C$   $D$   $E$ ,  $F$  and  $G$  of the sector.

Standard	identification of reference	Value of reference	Tolerance
ITER_GLOB /Not $B$	"NON_REGRESSION"	1	0.00%
ITER_GLOB /Not $C$	"NON_REGRESSION"	1	0.00%
ITER_GLOB /Not $D$	"NON_REGRESSION"	1	0.00%
ITER_GLOB /Not $E$	"NON_REGRESSION"	1	0.00%
ITER_GLOB /Not $F$	"NON_REGRESSION"	1	0.00%
ITER_GLOB /Not $G$	"NON_REGRESSION"	1	0.00%

One tests the state of the contact (field VALE\_CONT) when the point  $K$  of the piece is opposite the points understood enters  $E$  and  $F$  all them 5mm .

Standard	identification of reference	Value of reference	Tolerance
CONT /Not $E$	"NON_REGRESSION"	0	0.00%
CONT /Not $E + 5mm$	"NON_REGRESSION"	0	0.00%
CONT / Not $E + 10mm$	"NON_REGRESSION"	2	0.00%
CONT / Not $E + 15mm$	"NON_REGRESSION"	2	0.00%
CONT /Not $F$	"NON_REGRESSION"	2	0.00%

the first two points are not in contact.

## 6.4 Remarks

The computation is carried out by imposing a displacement on the back face of the piece (MN) . Displacement is imposed in the following way:

- of 0.mm with 5.mm in 5 steps
- of 5.mm with 20.mm in 5 steps
- of 20.mm 50.mm in 5 steps  
with
- of 50.mm 70.mm in 5 steps  
with
- of 70.mm 140.mm in 5 steps  
with
- of 140.mm 155.mm in 5 steps  
with

computations do not converge with the key keys by default used for convergence in STAT\_NON\_LINE, because the default value of RESI\_GLOB\_RELA = 1.E-6 is too constraining (forces to which the

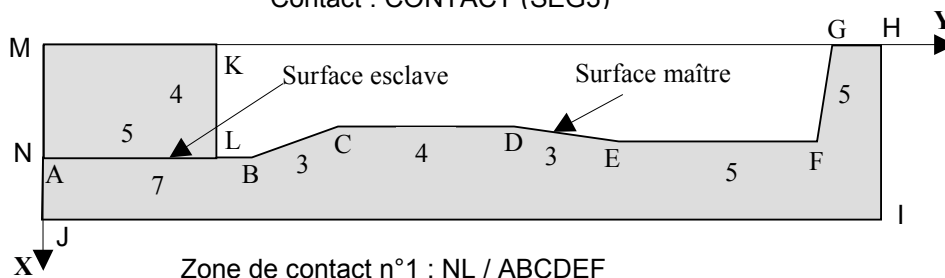
piece is subjected being at the beginning relatively weak). To mitigate this problem, it is necessary to use the key word `RESI_GLOB_MAXI = 1.E-6`.

## 7 Modelization E

### 7.1 Characteristic of the modelization

One uses a modelization `AXIS` (quadratic elements).

Solide : Modélisation `AXIS` (`TRIA6`)  
Contact : `CONTACT` (`SEG3`)



Zone de contact n°1 : NL / ABCDEF

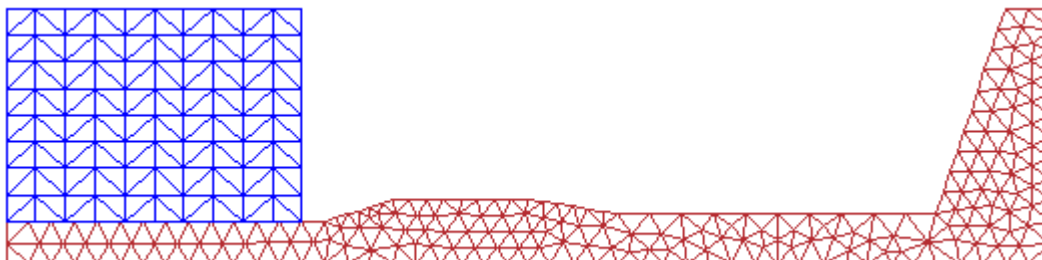
Conditions limites :

- cotés JA, IJ, HI :  $DX=0.$ ,  $DY=0.$
- coté MN :  $DY=1.$

The discrete formulation of the contact is used (method of the active stresses).

One uses here the function `SLIDE` which makes it possible to maintain the contact throughout extrusion, in a mathematical way. Result is physically close to the modelization without slide, since it is about an extrusion without friction.

### 7.2 Characteristics of the mesh



Many nodes: 1174

Number of meshes: 510 `TRIA6` and 152 `SEG3`

Many nodes in contact: 21

### 7.3 Quantities tested and results

the values of reference are regarded as being those of the modelization C.

One compared to the tests the following  $Y$  displacement of  $K$  the point of the piece surface  $ABCDEF$  of the sector.

Standard	identification of reference	Value of reference	Tolerance
Not $K$ /Not $B - DY$	"ANALYTIQUE"	5.0000	0.1%
Point $K$ /Not $F - DY$	"NON_REGRESSION"	144.2240	0.1%

## 7.4 Remarks

The computation is carried out by imposing a displacement on the back face of the piece (MN) . Displacement is imposed in the following way:

- of 0.mm with 5.mm in 5 steps
- of 5.mm with 20.mm in 5 steps
- of 20.mm 50.mm in 5 steps  
with
- of 50.mm 70.mm in 5 steps  
with
- of 70.mm 140.mm in 5 steps  
with

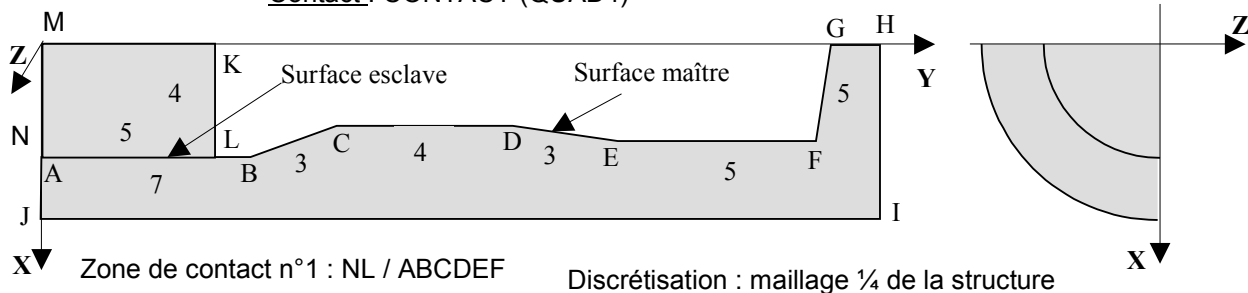
computations do not converge with the key keys by default used for convergence in `STAT_NON_LINE`, because the default value of `RESI_GLOB_RELA = 1.E-6` is too constraining (forces to which the piece is subjected being at the beginning relatively weak). To mitigate this problem, it is necessary to use the key word `RESI_GLOB_MAXI = 1.E-6`.

## 8 Modelization F

### 8.1 Characteristic of the modelization

One uses a modelization 3D (linear elements).

Solide : Modélisation 3D (HEXA8, PENTA6)  
Contact : CONTACT (QUAD4)



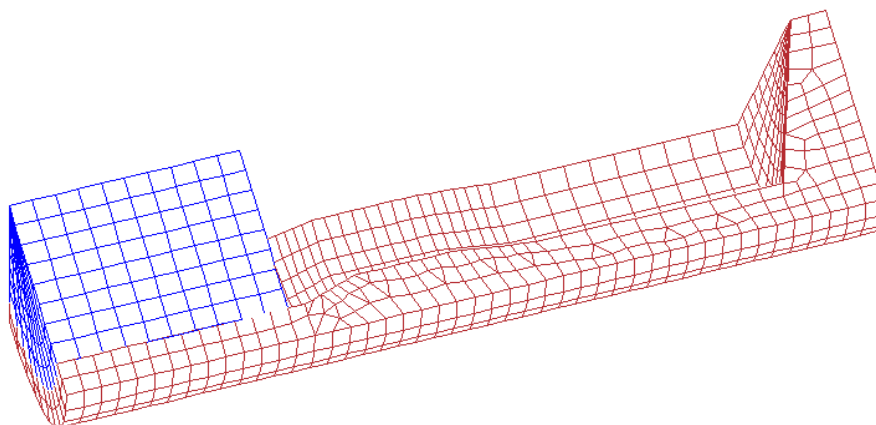
Conditions aux limites sur les groupes de nœuds suivants :

- 'FIL\_EXT' : groupe des nœuds situés sur la surface extérieure de la filière (HI, IJ, JA)  
=>  $DX=0.$ ,  $DY=0.$ ,  $DZ=0.$
- 'FIL\_SYM1' : Groupe des nœuds de la filière situés dans le plan XOY :  $DZ=0.$
- 'FIL\_SYM2' : Groupe des nœuds de la filière situés dans le plan YOZ :  $DX=0.$
- 'LOP\_SYM1' : Groupe des nœuds du lopin situés dans le plan XOY :  $DZ=0.$
- 'LOP\_SYM2' : Groupe des nœuds du lopin situés dans le plan YOZ :  $DX=0.$
- 'LOP\_DDL' : Groupe des nœuds situés sur la face arrière du lopin :  $DY=1$

The discrete formulation of the contact is used (method of the active stresses).

One uses here the function SLIDE which makes it possible to maintain the contact throughout extrusion, in a mathematical way. Result is physically close to the modelization without slide, since it is about an extrusion without friction.

### 8.2 Characteristics of the mesh



Many nodes: 3292

Number of meshes: 2150 HEXA8, 260 PENTA6, 1814 QUAD4 and 68 TRIA3

Many nodes in contact: 210

### 8.3 Quantities tested and results

the values of reference are regarded as being those of the modelization C. One compared to the tests the following  $Y$  displacement of  $K$  the point of the piece surface  $ABCDEFGG$  of the sector.

Standard	identification of reference	Value of reference	Tolerance
Not $K$ /Not $B - DY$	"ANALYTIQUE"	5.0000	1.0%
Point $K$ /Not $C - DY$	"ANALYTIQUE"	20.8250	1.8%
Point $K$ /Not $D - DY$	"ANALYTIQUE"	55.8800	1.1%
Point $K$ /Not $E - DY$	"ANALYTIQUE"	78.6900	1.0%
Point $K$ /Not $F - DY$	"ANALYTIQUE"	144.8950	1.0%
Point $K$ /Not $G - DY$	"ANALYTIQUE"	155.0960	3.0%

One tests the nombre of iterations of Newton when the point  $K$  of the piece is opposite the points  $B C D E, F$  and  $G$  of the sector.

Standard	identification of reference	Value of reference	Tolerance
ITER_GLOB /Not $B$	"NON_REGRESSION"	2	0.00%
ITER_GLOB /Not $C$	"NON_REGRESSION"	4	0.00%
ITER_GLOB /Not $D$	"NON_REGRESSION"	4	0.00%
ITER_GLOB /Not $E$	"NON_REGRESSION"	4	0.00%
ITER_GLOB /Not $F$	"NON_REGRESSION"	3	0.00%
ITER_GLOB /Not $G$	"NON_REGRESSION"	3	0.00%

## 8.4 Remarks

The computation is carried out by imposing a displacement on the back face of the piece (MN) . Displacement is imposed in the following way:

- of 0.mm with 5.mm in 5 steps
- of 5.mm with 15.mm in 10 steps
- of 15.mm 20.mm in 5 steps  
with
- of 20.mm 50.mm in 5 steps  
with
- of 50.mm 70.mm in 10 steps  
with
- of 70.mm 140.mm in 35 steps  
with

computations do not converge with the key keys by default used for convergence in STAT\_NON\_LINE, because the default value of RESI\_GLOB\_RELA = 1.E-6 is too constraining (forces to which the



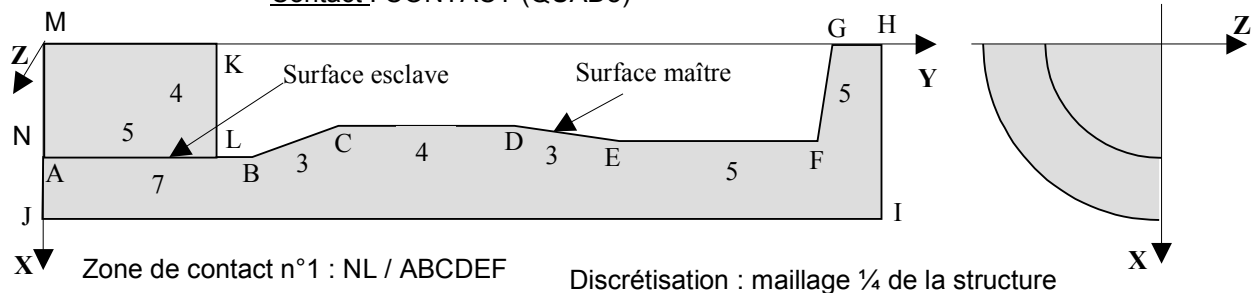
piece is subjected being at the beginning relatively weak). To mitigate this problem, it is necessary to use the key word `RESI_GLOB_MAXI = 1.E-6`.

## 9 Modelization G

### 9.1 Characteristic of the modelization

One uses a modelization 3D (quadratic elements).

Solide : Modélisation 3D (HEXA20, PENTA15)  
Contact : CONTACT (QUAD8)



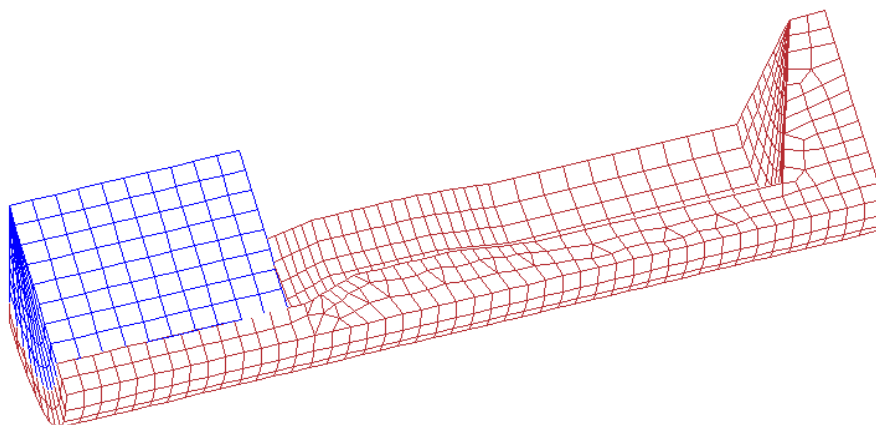
Conditions aux limites sur les groupes de nœuds suivants :

- 'FIL\_EXT' : groupe des nœuds situés sur la surface extérieure de la filière (HI, IJ, JA)  
=> DX=0., DY =0., DZ=0.
- 'FIL\_SYM1' : Groupe des nœuds de la filière situés dans le plan XOY : DZ=0.
- 'FIL\_SYM2' : Groupe des nœuds de la filière situés dans le plan YOZ : DX=0.
- 'LOP\_SYM1' : Groupe des nœuds du lopin situés dans le plan XOY : DZ=0.
- 'LOP\_SYM2' : Groupe des nœuds du lopin situés dans le plan YOZ : DX=0
- 'LOP\_DDL' : Groupe des nœuds situés sur la face arrière du lopin : DY =1

The discrete formulation of the contact is used (method of the active stresses).

One uses here the function `SLIDE` which makes it possible to maintain the contact throughout extrusion, in a mathematical way. Result is physically close to the modelization without slide, since it is about an extrusion without friction.

### 9.2 Characteristics of the mesh



Many nodes: 12213

Number of meshes: 2150 HEXA20, 260 PENTA15, 1814 QUAD8 and 68 TRIA6

Many nodes in contact: 341

### 9.3 Quantities tested and results

the values of reference are regarded as being those of the modelization C. One compared to the tests the following  $Y$  displacement of  $K$  the point of the piece surface  $ABCDEFG$  of the sector.

Standard	identification of reference	Value of reference	Tolerance
Not $K$ /Not $B - DY$	"ANALYTIQUE"	5.0000	1.0%
Point $K$ /Not $C - DY$	"ANALYTIQUE"	20.8250	2.0%
Point $K$ /Not $D - DY$	"ANALYTIQUE"	55.8800	2.0%
Point $K$ /Not $E - DY$	"ANALYTIQUE"	78.6900	1.0%
Point $K$ /Not $F - DY$	"ANALYTIQUE"	144.8950	1.0%
Point $K$ /Not $G - DY$	"ANALYTIQUE"	155.0960	5.0%

One tests the nombre of iterations of Newton when the point  $K$  of the piece is opposite the points  $B$   $C$   $D$   $E$ ,  $F$  and  $G$  of the sector.

Standard	identification of reference	Value of reference	Tolerance
ITER_GLOB /Not $B$	"NON_REGRESSION"	2	0.00%
ITER_GLOB /Not $C$	"NON_REGRESSION"	4	0.00%
ITER_GLOB /Not $D$	"NON_REGRESSION"	4	0.00%
ITER_GLOB /Not $E$	"NON_REGRESSION"	4	0.00%
ITER_GLOB /Not $F$	"NON_REGRESSION"	3	0.00%
ITER_GLOB /Not $G$	"NON_REGRESSION"	4	0.00%

## 9.4 Remarks

The computation is carried out by imposing a displacement on the back face of the piece (MN) . Displacement is imposed in the following way:

- of 0.mm with 5.mm in 5 steps
- of 5.mm with 15.mm in 10 steps
- of 15.mm 20.mm in 5 steps  
with
- of 20.mm 50.mm in 5 steps  
with
- of 50.mm 70.mm in 10 steps  
with
- of 70.mm 140.mm in 35 steps  
with

computations do not converge with the key keys by default used for convergence in STAT\_NON\_LINE, because the default value of RESI\_GLOB\_RELA = 1.E-6 is too constraining (forces to which the piece is subjected being at the beginning relatively weak). To mitigate this problem, it is necessary to use the key word RESI\_GLOB\_MAXI = 1.E-6.

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

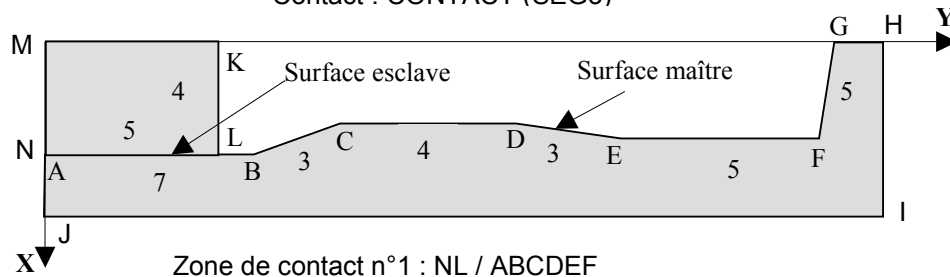


## 10 Modelization H

### 10.1 Characteristic of the modelization

One uses a modelization `AXIS` (quadratic elements).

Solide : Modélisation `AXIS` (`TRIA6`)  
Contact : `CONTACT` (`SEG3`)

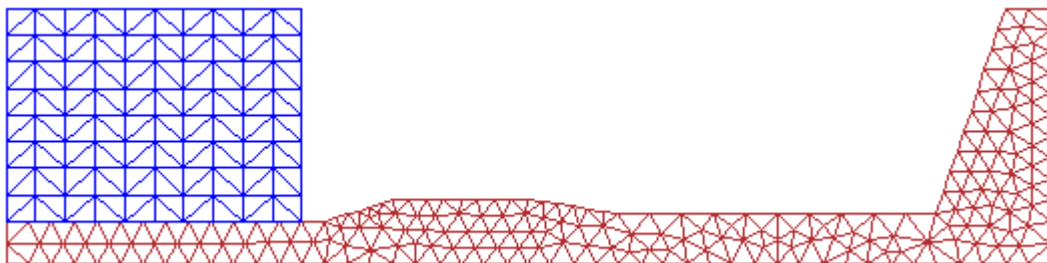


Conditions limites :

- cotés JA, IJ, HI :  $DX=0.$ ,  $DY=0.$
- coté MN :  $DY=1.$

One uses the formulation continues of the contact. This case - test present of the phenomena of flip-flop (oscillations of the statute of the contact related to a contact of the "shaving" type), to avoid this problem, one advances the piece of 10mm to the first step, the zone BC compressing the piece, it does not have there more problem.

### 10.2 Characteristics of the mesh



Many nodes: 1174

Number of meshes: 510 `TRIA6` and 152 `SEG3`

Many nodes in contact: 21

### 10.3 Quantities tested and results

the values of reference are regarded as being those of the modelization C.

One compared to the tests the following  $Y$  displacement of  $K$  the point of the piece surface  $ABCDEFGF$  of the sector.

Standard	identification of reference	Value of reference	Tolerance
Not $K$ /Not $B$ - $DY$	"NON_REGRESSION"	10,12	0.1%
Point $K$ /Not $F$ - $DY$	"NON_REGRESSION"	155,08	0.1%

## 10.4 Remarks

The computation is carried out by imposing a displacement on the back face of the piece (MN) . Computations do not converge with the key keys by default used for convergence in STAT\_NON\_LINE, because the default value of RESI\_GLOB\_RELA = 1.E-6 is too constraining (forces to which the piece is subjected being at the beginning relatively weak). To mitigate this problem, it is necessary to use the key word RESI\_GLOB\_MAXI = 1.E-6.

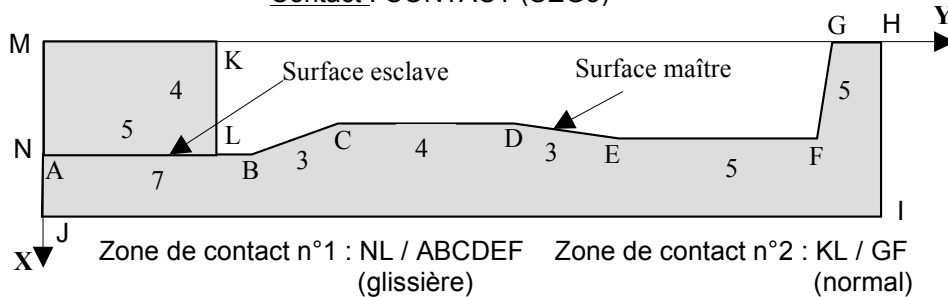
## 11 Modelization I

### 11.1 Characteristic of the modelization

One uses a modelization `AXIS` (quadratic elements).

`Solide` : Modélisation `AXIS` (`TRIA6`)

`Contact` : `CONTACT` (`SEG3`)

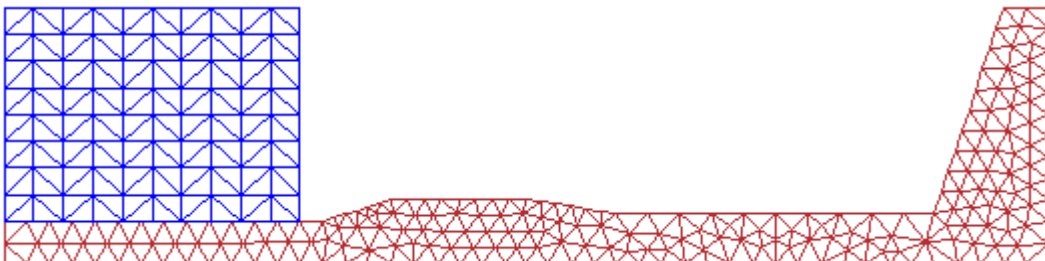


Conditions limites :

- cotés JA, IJ, HI :  $DX=0.$ ,  $DY=0.$
- coté MN :  $DY=1.$

One uses the formulation continues of the contact. This case - test is used to validate the functionality `CONTACT_INIT = "INTERPENETRATES"`. One uses here the function `SLIDE` which makes it possible to maintain the contact throughout extrusion, in a mathematical way. Result is physically close to the modelization without slide, since it is about an extrusion without friction.

### 11.2 Characteristics of the mesh



Many nodes: 1174

Number of meshes: 510 `TRIA6` and 152 `SEG3`

Many nodes in contact: 38

### 11.3 Quantities tested and results

the values of reference are regarded as being those of the modelization C.

One compared to the tests the following  $Y$  displacement of  $K$  the point of the piece surface  $ABCDEFGF$  of the sector.

Standard	identification of reference	Value of reference	Tolerance
Not $K$ /Not $B$ - $DY$	"ANALYTIQUE"	5.0000	0.1%
Point $K$ /Not $F$ - $DY$	"NON_REGRESSION"	144.9480	0.1%

## 11.4 Remarks

The computation is carried out by imposing a displacement on the back face of the piece (MN) .  
Displacement is imposed in the following way:

- of 0.mm with 5.mm in 5 steps
- of 5.mm with 20.mm in 15 step
- of 20.mm with 50.mm in 10 steps
- of 50.mm with 70.mm in 10 steps
- of 70.mm with 140.mm in 35 steps
- of 140.mm with 155.mm in 15 step

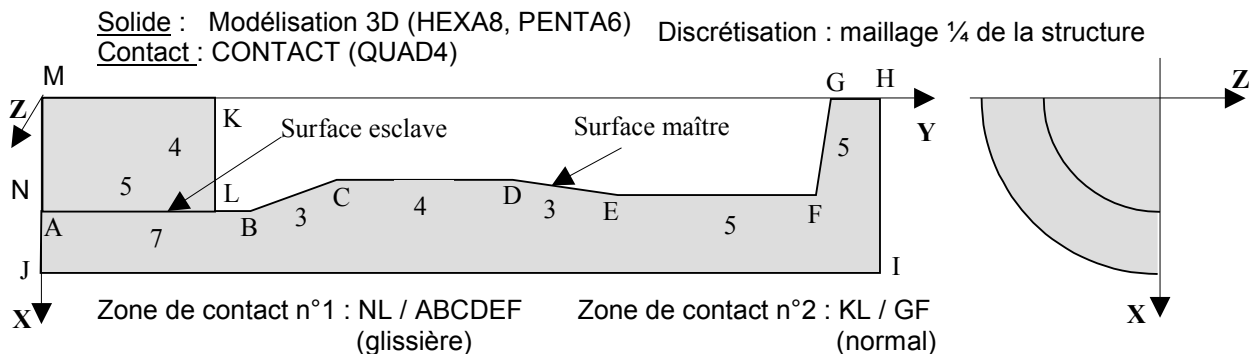
computations do not converge with the key keys by default used for convergence in `STAT_NON_LINE`, because the default value of `RESI_GLOB_RELA = 1.E-6` is too constraining (forces to which the piece is subjected being at the beginning relatively weak). To mitigate this problem, it is necessary to use the key word `RESI_GLOB_MAXI = 1.E-6`.



## 12 Modelization J

### 12.1 Characteristic of the modelization

One uses a modelization 3D (linear elements).

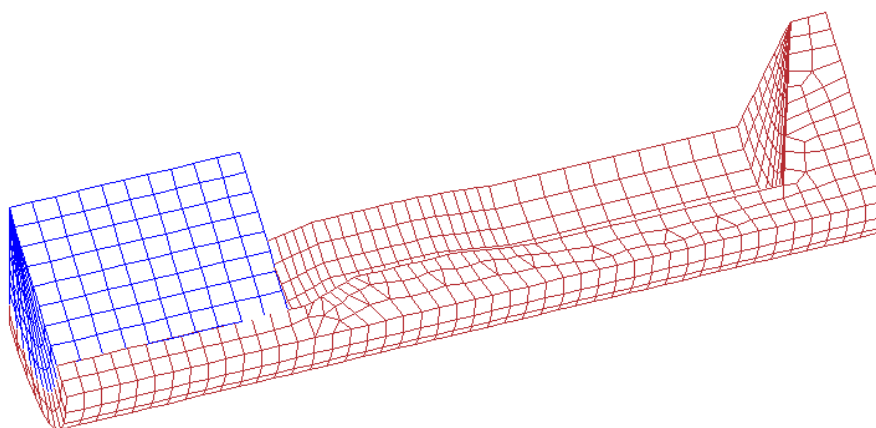


Conditions aux limites sur les groupes de nœuds suivants :

- 'FIL\_EXT' : groupe des nœuds situés sur la surface extérieure de la filière (HI, IJ, JA)  
=> DX=0., DY =0., DZ=0.
- 'FIL\_SYM1' : Groupe des nœuds de la filière situés dans le plan XOY : DZ=0.
- 'FIL\_SYM2' : Groupe des nœuds de la filière situés dans le plan YOZ : DX=0.
- 'LOP\_SYM1' : Groupe des nœuds du lopin situés dans le plan XOY : DZ=0.
- 'LOP\_SYM2' : Groupe des nœuds du lopin situés dans le plan YOZ : DX=0
- 'LOP\_DDL' : Groupe des nœuds situés sur la face arrière du lopin : DY =1

One uses the formulation continues of the contact. This case - test is used to validate the functionality CONTACT\_INIT = "INTERPENETRATES". One uses here the function SLIDE which makes it possible to maintain the contact throughout extrusion, in a mathematical way. Result is physically close to the modelization without slide, since it is about an extrusion without friction.

### 12.2 Characteristics of the mesh



Many nodes: 3292  
 Number of meshes: 2150 HEXA8, 260 PENTA6, 1814 QUAD4 and 68 TRIA63  
 Many nodes in contact: 210

### 12.3 Quantities tested and results

the values of reference are regarded as being those of the modelization C. One compared to the tests the following Y displacement of K the point of the piece surface ABCDEFG of the sector.

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

Standard	identification of reference	Value of reference	Tolerance
Not $K$ /Not $B - DY$	"ANALYTIQUE"	5.0000	0.10%
Point $K$ /Not $C - DY$	"ANALYTIQUE"	20.8250	2,0%
Point $K$ /Not $D - DY$	"ANALYTIQUE"	55.8800	1.50%
Point $K$ /Not $E - DY$	"ANALYTIQUE"	140,0	0,1%
Point $K$ /Not $F - DY$	"ANALYTIQUE"	155,0	0,1%

One tests the nombre of iterations of Newton when the point  $K$  of the piece is opposite the points  $B$   $C$   $D$ ,  $E$  and  $F$  of the sector.

Standard	identification of reference	Value of reference	Tolerance
ITER_GLOB /Not $B$	"NON_REGRESSION"	1	0.00%
ITER_GLOB /Not $C$	"NON_REGRESSION"	1	0.00%
ITER_GLOB /Not $D$	"NON_REGRESSION"	1	0,00%
ITER_GLOB /Not $E$	"NON_REGRESSION"	1	0.00%
ITER_GLOB /Not $F$	"NON_REGRESSION"	1	0,00%

## 12.4 Remarks

The computation is carried out by imposing a displacement on the back face of the piece (MN) . Displacement is imposed in the following way:

- of 0 mm with 20 mm in 4 steps
- of 20 mm with 70 mm in 5 steps
- of 70 mm with 140 mm in 2 steps
- of 140 mm 155 mm in 1 steps  
with

In this modelization, the external forces are sufficiently important and the use of an absolute convergence criterion is not compulsory because one slightly disturbed the conditions of symmetry on the piece.

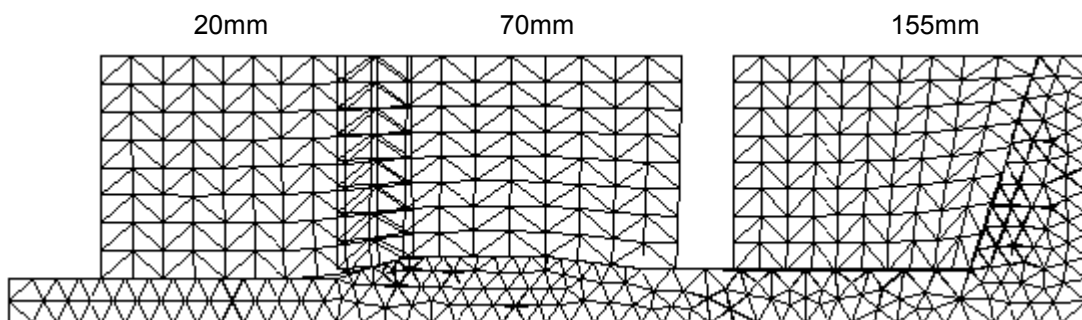
## 13 Summary of the results

the two modelizations (Axisymmetric and 3D) pass without problem. Convergence is fast. The results between the modelization `AXIS` and the modelization `3D` are similar.

In the same way, the methods `FORCED` and `CONTINUE` give also satisfactory results. On this example, the continuous method seems to converge more quickly than `FORCED`, in particular in `3D` with `SLIDE`.

For the typical case of the contact slide: the modelization `C` is then taken as reference. By the continuous method, one obtains solutions close to these values of reference, with generally a lower nombre of iterations.

On the figure above we present the position of the piece for a displacement of the back face of the piece of 20, 70, 155 mm.



This test made it possible to validate:

- the "transition" of geometrical singularities (acute angles and blunt),
- the taking into account of two contact zones (contact multi-zones),
- the modelization of a contact-slide.