

SSNV504 - Extrusion of a piece

Summary:

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 "passage" of geometrical singularities (acute angles and blunt) and to test the taking into account of two zones of contact (contact multi-zones).

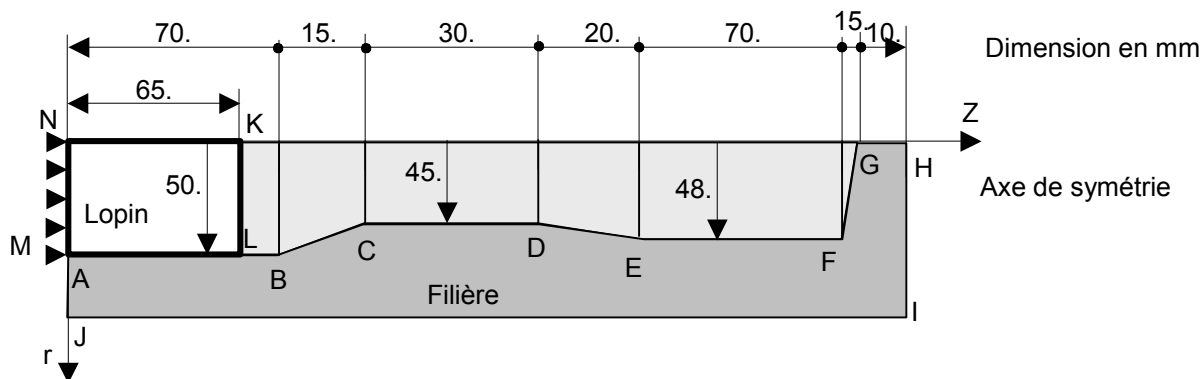
Modelings selected are the following ones:

- Modeling A (AXIS) : CONTACT node nets, associated with meshes SEG2,
- Modeling B (3D) : CONTACT node nets, associated with meshes QUAD4,
- Modeling C (AXIS) : CONTACT node nets SLIDE, associated with meshes SEG2,
- Modeling D (AXIS) : CONTACT, method CONTINUOUS associated with meshes SEG2,
- Modeling E (AXIS) : CONTACT node nets SLIDE, associated with meshes SEG3,
- Modeling F (3D) : CONTACT node nets SLIDE, associated with meshes QUAD4,
- Modeling G (3D) : CONTACT node nets SLIDE, associated with meshes QUAD8,
- Modeling H (2D) : CONTACT, method CONTINUOUS associated with SEG3,
- Modeling I (AXIS) : CONTACT SLIDE, method CONTINUOUS associated with SEG3,
- Modeling J (AXIS) : CONTACT SLIDE, method CONTINUOUS associated with QUAD4
- Modeling K (AXIS): Idem with modeling J: ALGO_CONT=STANDARD+PENALISATION

Modelings with SLIDE allow to maintain the contact throughout extrusion, in a mathematical way. The result is physically close to modeling without slide, since it is about an extrusion without friction.

1 Problem of reference

1.1 Geometry



1.2 Properties of material

Piece:

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

Sector:

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

Piece/sector

- $\mu = 0$ Coefficient of friction

1.3 Boundary conditions and loadings

Boundary conditions: lines HI , IJ and JA embedded

Loading: Piloting 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 objective of this CAS-test is to analyze the feasibility of calculation 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 modeling 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> sector
<i>K</i>	20,825	Piece in the vicinity of the point <i>C</i> sector
<i>K</i>	55,880	Piece in the vicinity of the point <i>D</i> sector
<i>K</i>	78,690	Piece in the vicinity of the point <i>E</i> sector
<i>K</i>	144,895	Piece in the vicinity of the point <i>F</i> sector
<i>K</i>	155,096	Piece at the point <i>G</i> sector

For calculation with checking of the contact without calculation (option `RESOLUTION='NON'`), the displacement of the face before piece and the interpenetration of surfaces are tested.

Piece (localization)	Displacement (mm)	Comments
<i>K</i>	155,096	Piece at the point <i>G</i> sector

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

2.3 Uncertainties on the solution

Lower than 0.1%

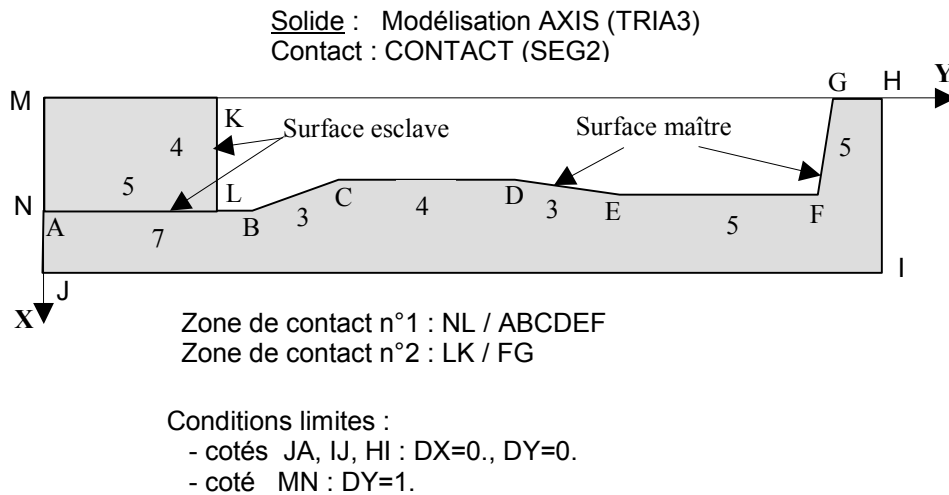
2.4 Bibliographical references

None

3 Modeling A

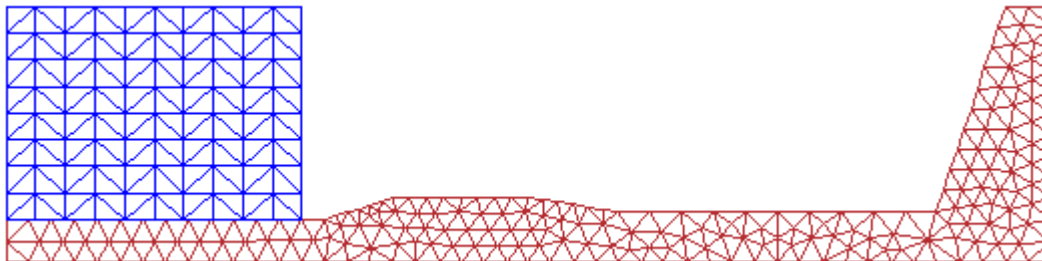
3.1 Characteristics of modeling

A modeling is used **AXIS** (linear elements).



One uses the discrete formulation of the contact (method of the active constraints).

3.2 Characteristics of the grid



Many nodes: 333
Many meshes: 510 **TRIA3** and 152 **SEG2**
Many nodes in contact: 20

3.3 Sizes tested and results

Following displacement is tested Y point K piece compared to surface $ABCDEFGF$ sector.

Identification	Type of reference	Value of reference	Tolerance
Not K / Not B - DY	'ANALYTICAL'	5,0000	0.1%
Not K / Not C - DY	'ANALYTICAL'	20,8250	0.1%
Not K / Not D - DY	'ANALYTICAL'	55,8800	0.2%
Not K / Not E -	'ANALYTICAL'	78,6900	0.1%

<i>DY</i>			
Not <i>K</i> / Not <i>F</i> - <i>DY</i>	'ANALYTICAL'	144,8950	0.1%
Not <i>K</i> / Not <i>G</i> - <i>DY</i>	'ANALYTICAL'	155,0960	0.1%

Checking of the mode RESOLUTION=' NON' :

Identification	Type of reference	Value of reference	Tolerance
Not <i>K</i> / Not <i>G</i> - <i>DY</i>	'ANALYTICAL'	155,0960	0.1%
Game <i>LC</i>	'ANALYTICAL'	-5,0000	0.1%
Game <i>LE</i>	'ANALYTICAL'	-2,0000	0.1%

3.4 Remarks

Calculation 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 pas
- of 5.mm with 20.mm in 5 pas
- of 20.mm with 50.mm in 5 pas
- of 50.mm with 70.mm in 5 pas
- of 70.mm with 140.mm in 5 pas
- of 140.mm 155.mm in 5 pas
with

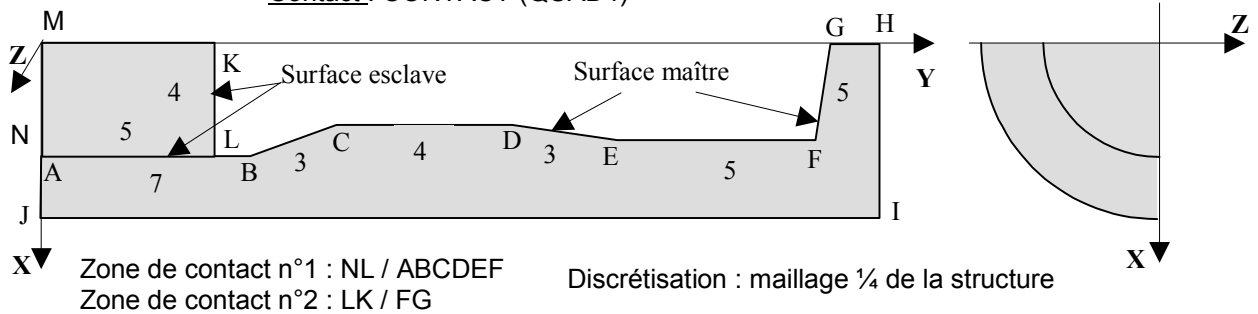
Calculations do not converge with the keywords by default used for convergence in STAT_NON_LINE, because the value by default of RESI_GLOB_RELA = 1.E-6 is too constraining (the forces to which the piece is subjected being at the beginning relatively weak). To mitigate this problem, the keyword should be used RESI_GLOB_MAXI = 1.E-6.

4 Modeling B

4.1 Characteristics of modeling

A modeling is used 3D (linear elements).

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

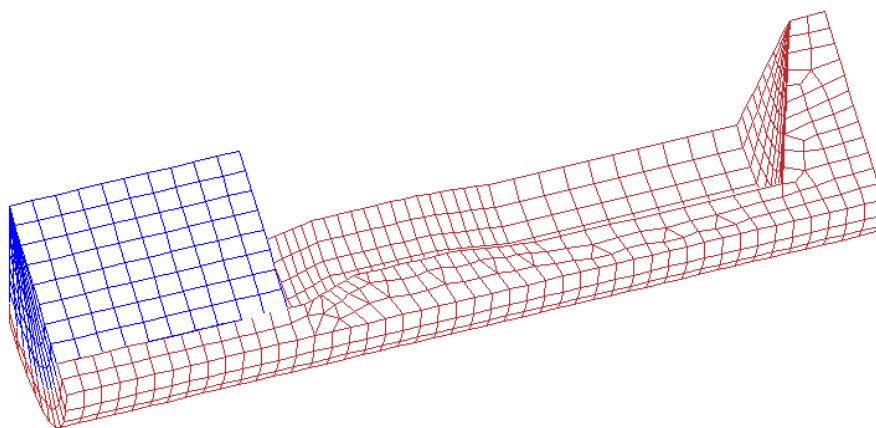


Conditions aux limites sur les groupes de nœuds suivants :

- '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

One uses the discrete formulation of the contact (method of the active constraints).

4.2 Characteristics of the grid



Many nodes: 3292
Many meshes: 2150 HEXA8, 260 PENTA6, 1814 QUAD4 and 68 TRIA3
Many nodes in contact: 210

4.3 Sizes tested and results

Following displacement is tested Y point K piece compared to surface $ABCDEFGF$ sector.

Identification	Type of reference	Value of reference	Tolerance
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Not K / Not $B - DY$	'ANALYTICAL'	5,0000	0.1%
Not K / Not $C - DY$	'ANALYTICAL'	20,8250	1.0%
Not K / Not $D - DY$	'ANALYTICAL'	55,8800	1.0%
Not K / Not $E - DY$	'ANALYTICAL'	78,6900	1.0%
Not K / Not $F - DY$	'ANALYTICAL'	144,8950	1.0%
Not K / Not $G - DY$	'ANALYTICAL'	155,0960	1.0%

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

Identification	Type 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

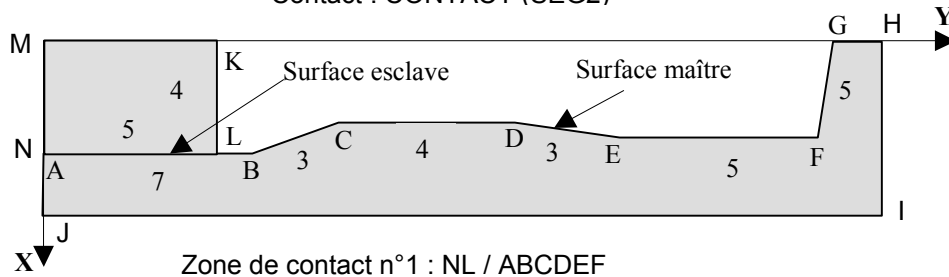
- Calculation is carried out by imposing a displacement on the back face of the piece (MN) . Displacement is imposed in the following way:
 - of 0.mm with 5.mm in 5 pas
 - of 5.mm with 15.mm in 10 pas
 - of 5.mm with 20.mm in 5 pas
 - of 20.mm 50.mm in 5 pas
with
 - of 50.mm 70.mm in 10 pas
with
 - of 70.mm 140.mm in 35 pas
with
 - of 140.mm 155.mm in 15 pas
with
- Calculations do not converge with the keywords by default used for convergence in STAT_NON_LINE, because the value by default of RESI_GLOB_RELA = 1.E-6 is too constraining (the forces to which the piece is subjected being at the beginning relatively weak). To mitigate this problem, the keyword should be used RESI_GLOB_MAXI = 1.E-6.

5 Modeling C

5.1 Characteristics of modeling

A modeling is used `AXIS` (linear elements).

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



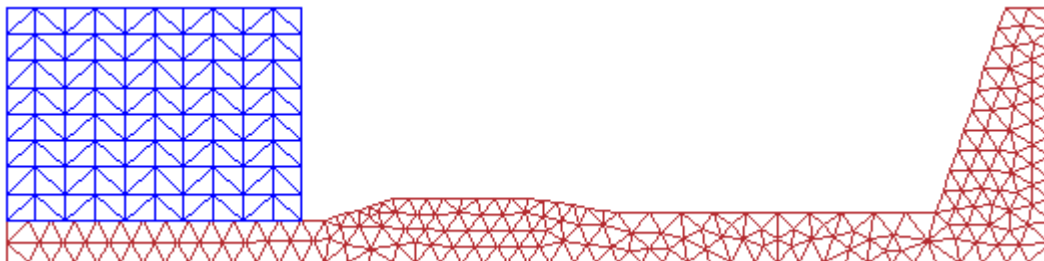
Conditions limites :

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

One uses the discrete formulation of the contact (method of the active constraints).

The function here is used `SLIDE` who allows to maintain the contact throughout extrusion, in a mathematical way. The result is physically close to modeling without slide, since it is about an extrusion without friction.

5.2 Characteristics of the grid



Many nodes: 333

Many meshes: 510 `TRIA3` and 152 `SEG2`

Many nodes in contact: 20

5.3 Sizes tested and results

Following displacement is tested Y point K piece compared to surface $ABCDEFGF$ sector.

Identification	Type of reference	Value of reference	Tolerance
Not K / Not B - DY	'ANALYTICAL'	5,0000	0.1%
Not K / Not F - DY	'NON_REGRESSION'	144,2240	0.1%

5.4 Remarks

Calculation 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 pas
- of 5.mm with 20.mm in 5 pas
- of 20.mm 50.mm in 5 pas
with
- of 50.mm 70.mm in 5 pas
with
- of 70.mm 140.mm in 5 pas
with

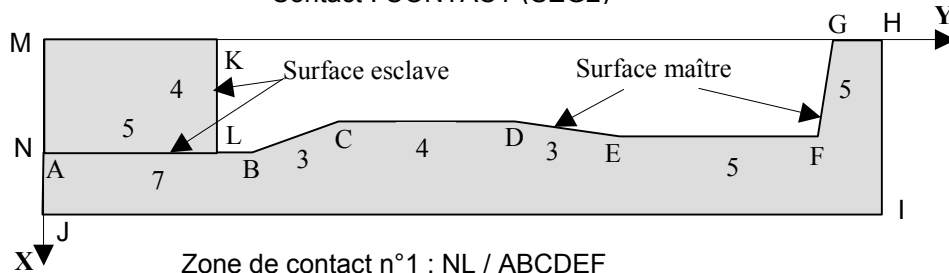
Calculations do not converge with the keywords by default used for convergence in `STAT_NON_LINE`, because the value by default of `RESI_GLOB_RELA = 1.E-6` is too constraining (the forces to which the piece is subjected being at the beginning relatively weak). To mitigate this problem, the keyword should be used `RESI_GLOB_MAXI = 1.E-6`.

6 Modeling D

6.1 Characteristics of modeling

A modeling is used `AXIS` (linear elements).

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

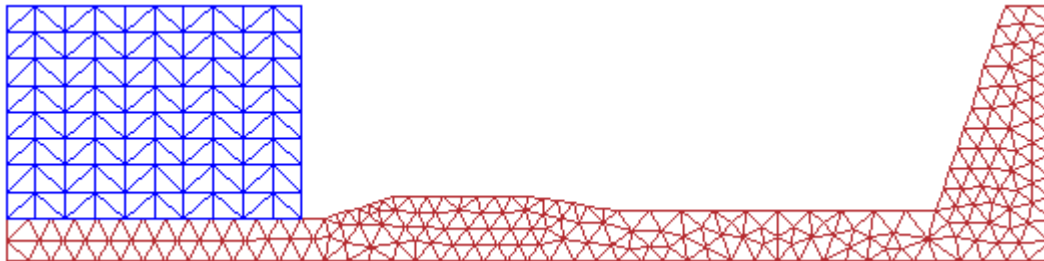


Zone de contact n°1 : NL / ABCDEF
Zone de contact n°2 : LK / FG

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

One uses the formulation continues contact.

6.2 Characteristics of the grid



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

6.3 Sizes tested and results

Following displacement is tested Y point K piece compared to surface $ABCDEFGF$ sector.

Identification	Type of reference	Value of reference	Tolerance
Not K / Not B - DY	'ANALYTICAL'	5,0000	0.1%
Not K / Not C - DY	'ANALYTICAL'	20,8250	0.2%
Not K / Not D - DY	'ANALYTICAL'	55,8800	0.2%
Not K / Not E - DY	'ANALYTICAL'	78,6900	0.1%

Not K / Not F - DY	'ANALYTICAL'	144,8950	0.1%
Not K / Not G - DY	'ANALYTICAL'	155,0960	0.1%

One tests the iteration count of Newton when the point K piece is opposite as of points B , C , D , E , F and G sector.

Identification	Type 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 `CONT_NOEU`) when the point K piece is opposite the points understood enters E and F and all them 5mm .

Identification	Type 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

Calculation 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 pas
- of 5.mm with 20.mm in 5 pas
- of 20.mm 50.mm in 5 pas
with
- of 50.mm 70.mm in 5 pas
with
- of 70.mm 140.mm in 5 pas
with
- of 140.mm 155.mm in 5 pas
with

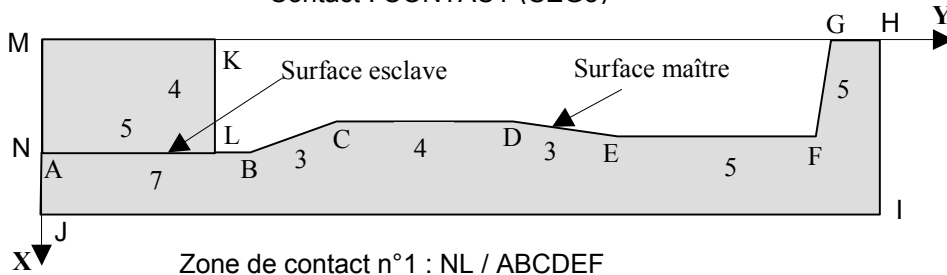
Calculations do not converge with the keywords by default used for convergence in `STAT_NON_LINE`, because the value by default of `RESI_GLOB_RELA` = 1.E-6 is too constraining (the forces to which the piece is subjected being at the beginning relatively weak). To mitigate this problem, the keyword should be used `RESI_GLOB_MAXI` = 1.E-6.

7 Modeling E

7.1 Characteristics of modeling

A modeling is used **AXIS** (quadratic elements).

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



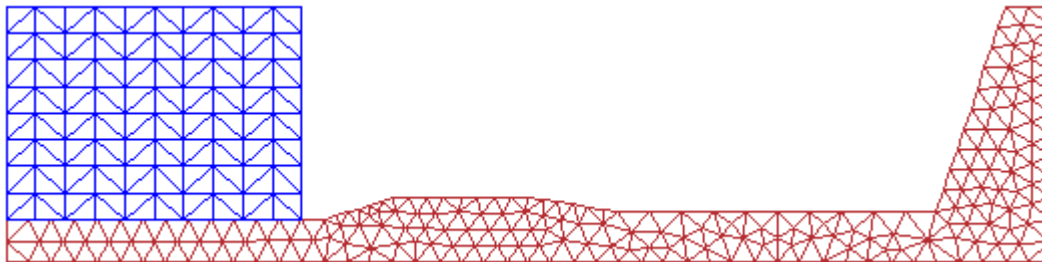
Conditions limites :

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

One uses the discrete formulation of the contact (method of the active constraints).

The function here is used **SLIDE** who allows to maintain the contact throughout extrusion, in a mathematical way. The result is physically close to modeling without slide, since it is about an extrusion without friction.

7.2 Characteristics of the grid



Many nodes: 1174

Many meshes: 510 **TRIA6** and 152 **SEG3**

Many nodes in contact: 21

7.3 Sizes tested and results

The values of reference are regarded as being those of modeling C.

Following displacement is tested **Y** point **K** piece compared to surface **ABCDEFGF** sector.

Identification	Type of reference	Value of reference	Tolerance
Not K / Not B - <i>DY</i>	'ANALYTICAL'	5,0000	0.1%
Not K / Not F - <i>DY</i>	'NON_REGRESSION'	144,2240	0.1%

7.4 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.

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Calculation 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 pas
- of 5.mm with 20.mm in 5 pas
- of 20.mm 50.mm in 5 pas
with
- of 50.mm 70.mm in 5 pas
with
- of 70.mm 140.mm in 5 pas
with

Calculations do not converge with the keywords by default used for convergence in `STAT_NON_LINE`, because the value by default of `RESI_GLOB_RELA = 1.E-6` is too constraining (the forces to which the piece is subjected being at the beginning relatively weak). To mitigate this problem, the keyword should be used `RESI_GLOB_MAXI = 1.E-6`.

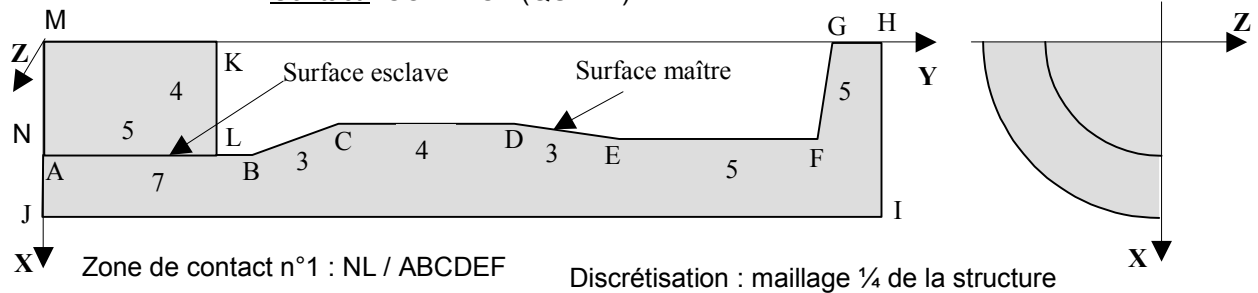
8 Modeling F

8.1 Characteristics of modeling

A modeling is used 3D (linear elements).

Solide : Modélisation 3D (HEXA8, PENTA6)

Contact : CONTACT (QUAD4)



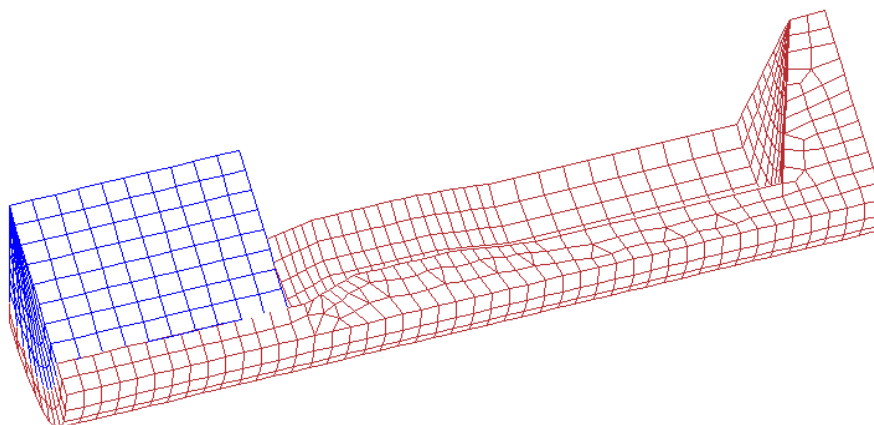
Conditions aux limites sur les groupes de nœuds suivants :

- '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 : $DY=1$

One uses the discrete formulation of the contact (method of the active constraints).

The function here is used `SLIDE` who allows to maintain the contact throughout extrusion, in a mathematical way. The result is physically close to modeling without slide, since it is about an extrusion without friction.

8.2 Characteristics of the grid



Many nodes: 3292

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

Many nodes in contact: 210

8.3 Sizes tested and results

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

Identification	Type of reference	Value of reference	Tolerance
Not K / Not $B - DY$	'ANALYTICAL'	5,0000	1.0%
Not K / Not $C - DY$	'ANALYTICAL'	20,8250	1.8%
Not K / Not $D - DY$	'ANALYTICAL'	55,8800	1.1%
Not K / Not $E - DY$	'ANALYTICAL'	78,6900	1.0%
Not K / Not $F - DY$	'ANALYTICAL'	144,8950	1.0%
Not K / Not $G - DY$	'ANALYTICAL'	155,0960	3.0%

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

Identification	Type 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

Calculation 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 pas
- of 5.mm with 15.mm in 10 pas
- of 15.mm 20.mm in 5 pas
with
- of 20.mm 50.mm in 5 pas
with
- of 50.mm 70.mm in 10 pas
with
- of 70.mm 140.mm in 35 pas
with

Calculations do not converge with the keywords by default used for convergence in STAT_NON_LINE, because the value by default of RESI_GLOB_RELA = 1.E-6 is too constraining (the forces to which the piece is subjected being at the beginning relatively weak). To mitigate this problem, the keyword should be used RESI_GLOB_MAXI = 1.E-6.

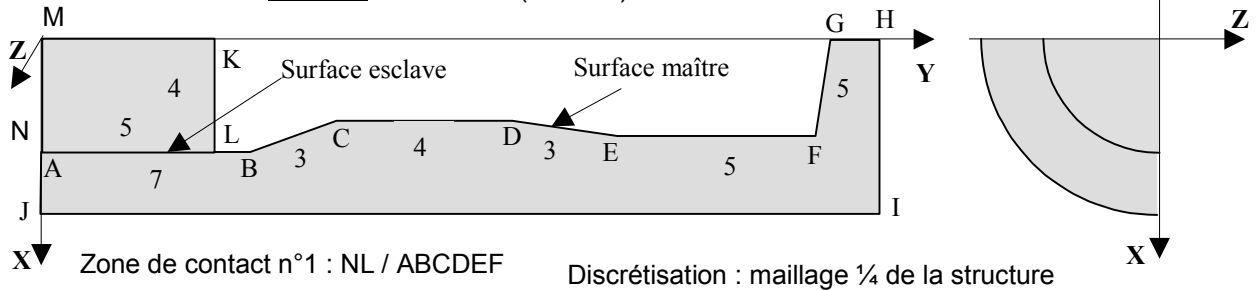
9 Modeling G

9.1 Characteristics of modeling

A modeling is used 3D (quadratic elements).

Solide : Modélisation 3D (HEXA20, PENTA15)

Contact : CONTACT (QUAD8)



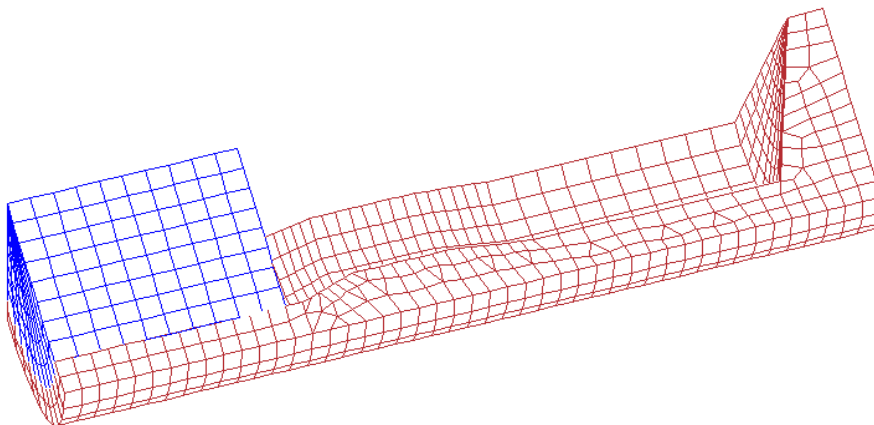
Conditions aux limites sur les groupes de nœuds suivants :

- '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

One uses the discrete formulation of the contact (method of the active constraints).

The function here is used `SLIDE` who allows to maintain the contact throughout extrusion, in a mathematical way. The result is physically close to modeling without slide, since it is about an extrusion without friction.

9.2 Characteristics of the grid



Many nodes: 12213

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

Many nodes in contact: 341

9.3 Sizes tested and results

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

Identification	Type of reference	Value of reference	Tolerance
Not K / Not $B - DY$	'ANALYTICAL'	5,0000	1.0%
Not K / Not $C - DY$	'ANALYTICAL'	20,8250	2.0%
Not K / Not $D - DY$	'ANALYTICAL'	55,8800	2.0%
Not K / Not $E - DY$	'ANALYTICAL'	78,6900	1.0%
Not K / Not $F - DY$	'ANALYTICAL'	144,8950	1.0%
Not K / Not $G - DY$	'ANALYTICAL'	155,0960	5.0%

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

Identification	Type 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

Calculation 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 pas
- of 5.mm with 15.mm in 10 pas
- of 15.mm 20.mm in 5 pas
with
- of 20.mm 50.mm in 5 pas
with
- of 50.mm 70.mm in 10 pas
with
- of 70.mm 140.mm in 35 pas
with

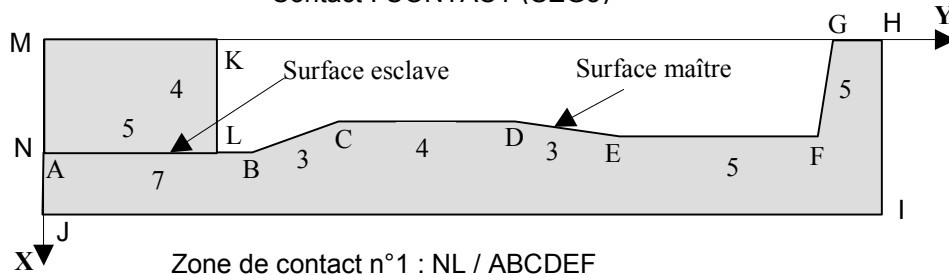
Calculations do not converge with the keywords by default used for convergence in STAT_NON_LINE, because the value by default of RESI_GLOB_RELA = 1.E-6 is too constraining (the forces to which the piece is subjected being at the beginning relatively weak). To mitigate this problem, the keyword should be used RESI_GLOB_MAXI = 1.E-6.

10 Modeling H

10.1 Characteristics of modeling

A modeling is used **AXIS** (quadratic elements).

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

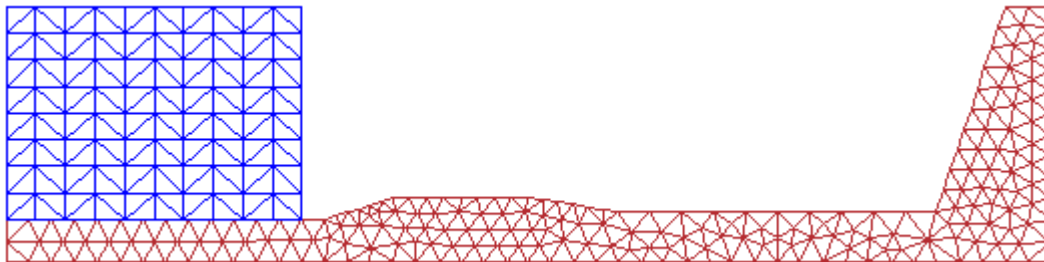


Conditions limites :

- côtés JA, IJ, HI : $DX=0.$, $DY=0.$
- côté MN : $DY=1.$

One uses the formulation continues 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, zone BC compressing the piece, it does not have there more problem.

10.2 Characteristics of the grid



Many nodes: 1174
Many meshes: 510 **TRIA6** and 152 **SEG3**
Many nodes in contact: 21

10.3 Sizes tested and results

The values of reference are regarded as being those of modeling C.

Following displacement is tested Y point K piece compared to surface $ABCDEFGG$ sector.

Identification	Type of reference	Value of reference	Tolerance
Not K / Not B - DY	'NON_REGRESSION'	10,12	0.1%
Not K / Not F - DY	'NON_REGRESSION'	155,08	0.1%

10.4 Remarks

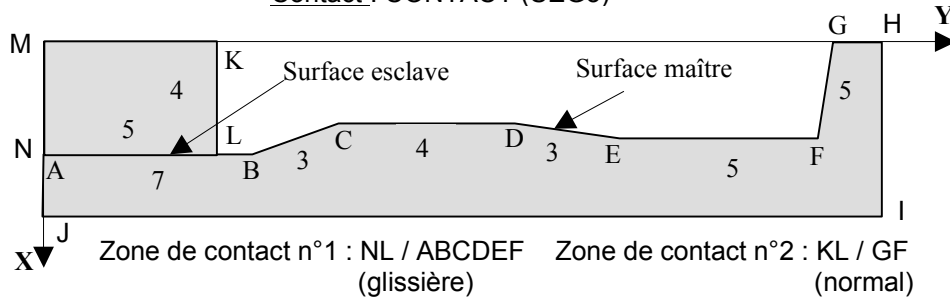
Calculation is carried out by imposing a displacement on the back face of the piece (MN) .
Calculations do not converge with the keywords by default used for convergence in STAT_NON_LINE, because the value by default of RESI_GLOB_RELA = 1.E-6 is too constraining (the forces to which the piece is subjected being at the beginning relatively weak). To mitigate this problem, the keyword should be used RESI_GLOB_MAXI = 1.E-6.

11 Modeling I

11.1 Characteristics of modeling

A modeling is used `AXIS` (quadratic elements).

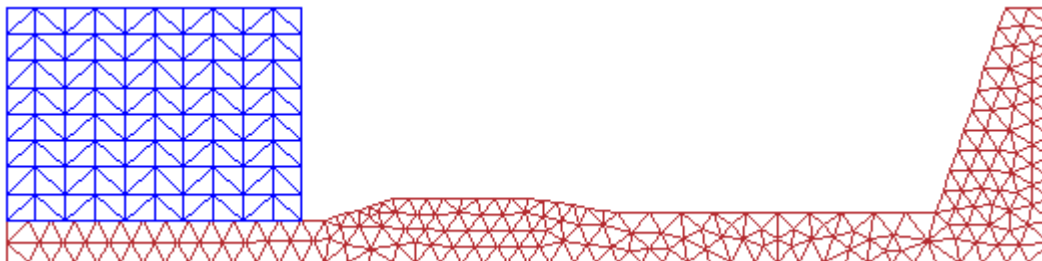
`Solide` : Modélisation `AXIS` (`TRIA6`)
`Contact` : `CONTACT` (`SEG3`)



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

One uses the formulation continues contact. This case - test is used to validate the functionality `CONTACT_INIT = 'INTERPENETRATES'`. The function here is used `SLIDE` who allows to maintain the contact throughout extrusion, in a mathematical way. The result is physically close to modeling without slide, since it is about an extrusion without friction.

11.2 Characteristics of the grid



Many nodes: 1174
Many meshes: 510 `TRIA6` and 152 `SEG3`
Many nodes in contact: 38

11.3 Sizes tested and results

The values of reference are regarded as being those of modeling C.
Following displacement is tested `Y` point `K` piece compared to surface `ABCDEFGF` sector.

Identification	Type of reference	Value of reference	Tolerance
Not <code>K</code> / Not <code>B</code> - <code>DY</code>	'ANALYTICAL'	5,0000	0.1%
Not <code>K</code> / Not <code>F</code> - <code>DY</code>	'NON_REGRESSION'	144,9480	0.1%

11.4 Remarks

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

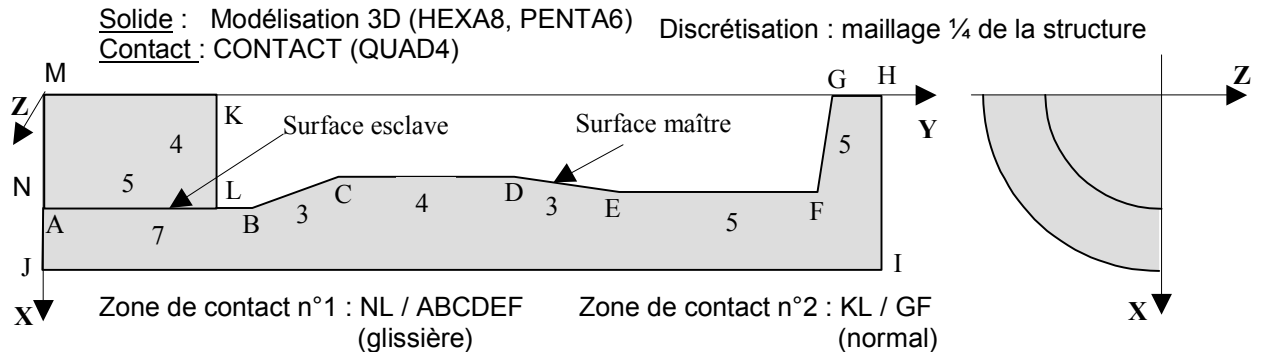
- of 0.mm with 5.mm in 5 pas
- of 5.mm with 20.mm in 15 pas
- of 20.mm with 50.mm in 10 pas
- of 50.mm with 70.mm in 10 pas
- of 70.mm with 140.mm in 35 pas
- of 140.mm with 155.mm in 15 pas

Calculations do not converge with the keywords by default used for convergence in `STAT_NON_LINE`, because the value by default of `RESI_GLOB_RELA = 1.E-6` is too constraining (the forces to which the piece is subjected being at the beginning relatively weak). To mitigate this problem, the keyword should be used `RESI_GLOB_MAXI = 1.E-6`.

12 Modeling J

12.1 Characteristics of modeling

A modeling is used 3D (linear elements).

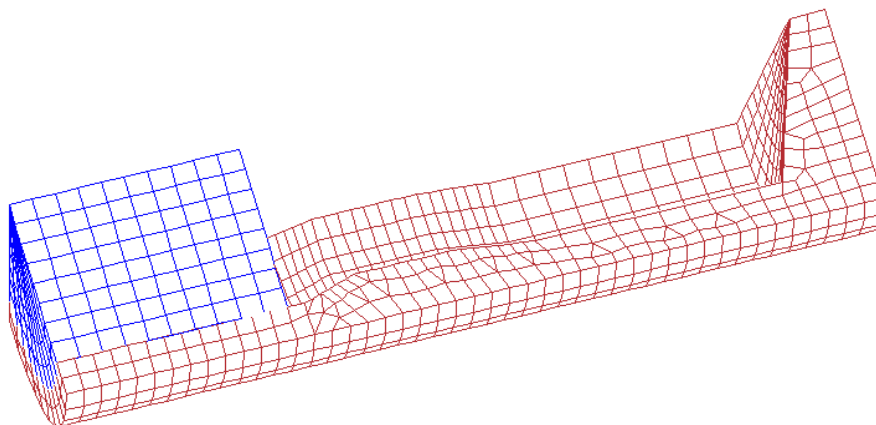


Conditions aux limites sur les groupes de nœuds suivants :

- '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 contact. This case - test is used to validate the functionality CONTACT_INIT = 'INTERPENETRATES'. The function here is used SLIDE who allows to maintain the contact throughout extrusion, in a mathematical way. The result is physically close to modeling without slide, since it is about an extrusion without friction.

12.2 Characteristics of the grid



Many nodes: 3292

Many meshes: 2150 HEXA8, 260 PENTA6, 1814 QUAD4 and 68 TRIA63

Many nodes in contact: 210

12.3 Sizes tested and results

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

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Identification	Type of reference	Value of reference	Tolerance
Not <i>K</i> / Not <i>B</i> - <i>DY</i>	'ANALYTICAL'	5,0000	0,10%
Not <i>K</i> / Not <i>C</i> - <i>DY</i>	'ANALYTICAL'	20,8250	2.0%
Not <i>K</i> / Not <i>D</i> - <i>DY</i>	'ANALYTICAL'	55,8800	1,50%
Not <i>K</i> / Not <i>E</i> - <i>DY</i>	'ANALYTICAL'	140.0	0.1%
Not <i>K</i> / Not <i>F</i> - <i>DY</i>	'ANALYTICAL'	155.0	0.1%

One tests the iteration count of Newton when the point *K* piece is opposite the points *B* , *C* , *D* , *E* and *F* sector.

Identification	Type of reference	Value of reference	Tolerance
ITER_GLOB / Not <i>B</i>	'NON_REGRESSION'	1	0,00%
ITER_GLOB / Not <i>C</i>	'NON_REGRESSION'	1	0,00%
ITER_GLOB / Not <i>D</i>	'NON_REGRESSION'	1	0.00%
ITER_GLOB / Not <i>E</i>	'NON_REGRESSION'	1	0,00%
ITER_GLOB / Not <i>F</i>	'NON_REGRESSION'	1	0.00%

12.4 Remarks

Calculation 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 pas
- of 20 mm with 70 mm in 5 pas
- of 70 mm with 140 mm in 2 pas
- of 140 mm 155 mm in 1 pas
with

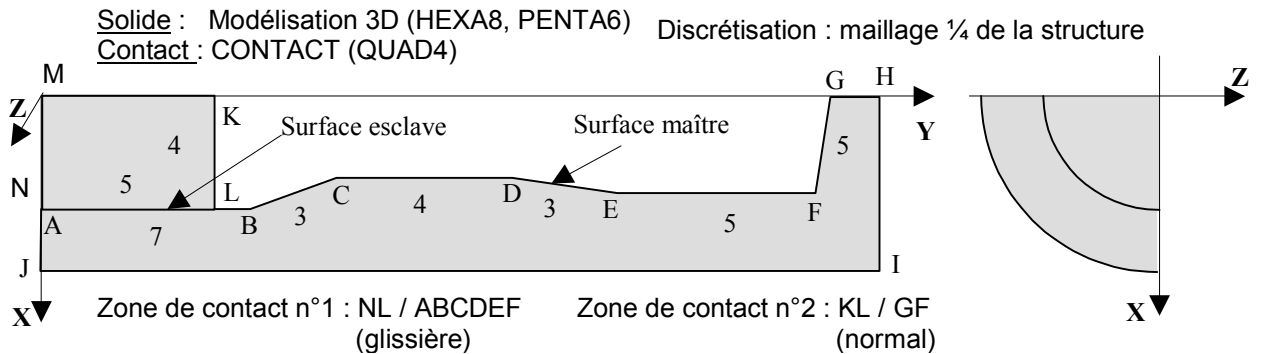
In this modeling, the external forces are sufficiently important and the use of absolute convergence criteria is not obligatory because one slightly disturbed the conditions of symmetry on the piece.

13 Modeling K

13.1 Characteristics of modeling

One uses the same ingredients as modeling J while combining ALGO_CONT=STANDARD for zone 1 with SLIDE with ALGO_CONT=PENALISATION for zone 2.

A modeling is used 3D (linear elements).

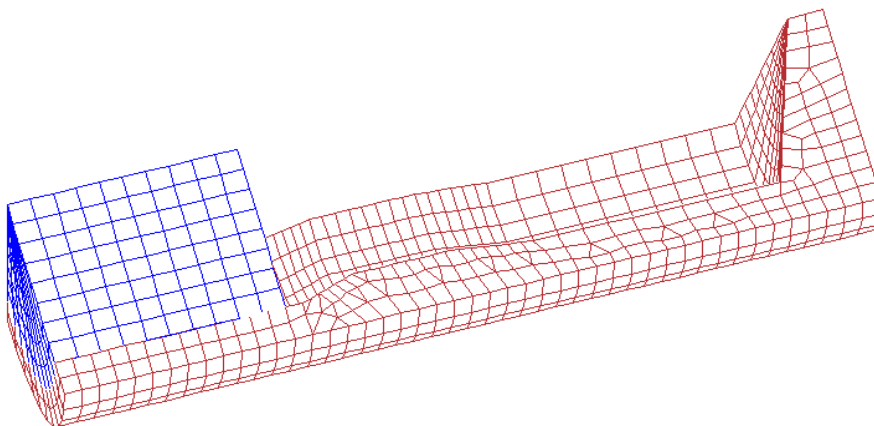


Conditions aux limites sur les groupes de nœuds suivants :

- '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 contact. This case - test is used to validate the functionality CONTACT_INIT = 'INTERPENETRATES'. The function here is used SLIDE who allows to maintain the contact throughout extrusion, in a mathematical way. The result is physically close to modeling without slide, since it is about an extrusion without friction.

13.2 Characteristics of the grid



Many nodes: 3292

Many meshes: 2150 HEXA8, 260 PENTA6, 1814 QUAD4 and 68 TRIA63

Many nodes in contact: 210

13.3 Sizes tested and results

The values of reference are regarded as being those of modeling C. One tests following displacement Y point K piece compared to surface $ABCDEFGF$ sector.

Identification	Type of reference	Value of reference	Tolerance
Not K / Not $B - DY$	'ANALYTICAL'	5,0000	0,10%
Not K / Not $C - DY$	'ANALYTICAL'	20,8250	2.0%
Not K / Not $D - DY$	'ANALYTICAL'	55,8800	1,50%
Not K / Not $E - DY$	'ANALYTICAL'	140.0	0,2%
Not K / Not $F - DY$	'ANALYTICAL'	155.0	0,2%

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

Identification	Type 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%

13.4 Remarks

Calculation 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 pas
- of 20 mm with 70 mm in 5 pas
- of 70 mm with 140 mm in 2 pas
- of 140 mm 155 mm in 1 pas
with

In this modeling, the external forces are sufficiently important and the use of absolute convergence criteria is not obligatory because one slightly disturbed the conditions of symmetry on the piece.

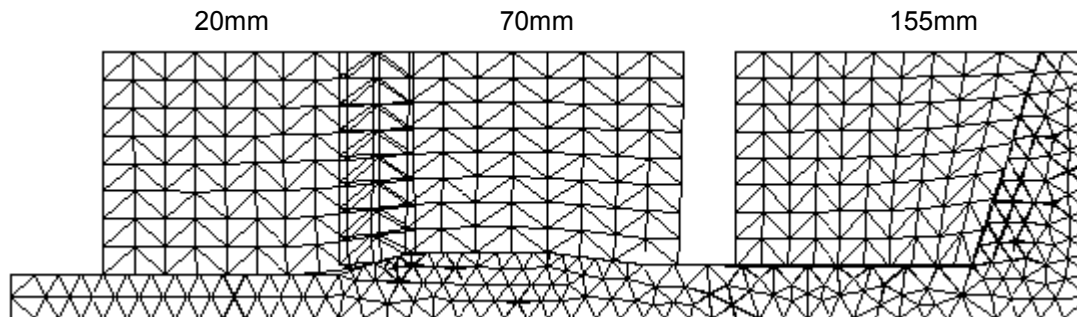
14 Summary of the results

Two modelings (Axisymmetric and 3D) pass without problem. Convergence is fast. Results between modeling `AXIS` and modeling `3D` are similar.

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

For the typical case of the contact slide: modeling `C` is then taken as reference. By the method `CONTINUOUS`, one obtains solutions close to these values of reference, with generally a lower iteration count.

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 “passage” of geometrical singularities (acute angles and blunt),
- the taking into account of two zones of contact (contact multi-zones),
- the modeling of a contact-slide.