Macro order `MACR_ASCOUF_MAIL`

1 Goal

To generate the grid of a healthy elbow or comprising a crack or one or more under-thicknesses.

The lengths must be given in millimetres and the angles in degrees.

The concept produced by this macro-order is of standard grid, containing the topological entities making it possible to apply boundary conditions and loadings. The produced grid can be used only or associated with the macro-order `MACR_ASCOUF_CALC`.

`MACR_ASCOUF_MAIL` rest on parametric procedures GIBI of grid of plates with defects. This grid is then transformed into grid of tube or elbow per call to the order `MODI_MAILLAGE`.

To use `MACR_ASCOUF_MAIL`, it is thus necessary to be able to reach to GIBI on the same object computer of *Code_Aster* (either all locally, or on the central machine *Aster*).

Product a concept of the type `grid`.

Contents

2 Syntax

```
netted [grid] = MACR_ASCOUF_MAIL

(
  ♦  EXEC_MAILLAGE =_F ( ♦  SOFTWARE    =  /  'GIBI2000',        [DEFECT]
                                            /  'GIBI98'  ,
                         ◊  UNITE_DATG  =  / unit_d  ,         [I]
                                           / 70      ,         [DEFECT]
                         ◊  UNITE_MGIB  =  / unit_s  ,         [I]
                                           / 19      ,         [DEFECT]
                         ◊  NIVE_GIBI   =  / 10      ,         [DEFECT]
                                           / 3,4,5,6,7,8,9,11  [I]
                       )

   ◊ TYPE_ELEM =      /  'CU20' ,                               [DEFECT]
                      /  'CUB8' ,

   ♦ ELBOW =_F    (  ♦  ANGLE          =  alpha,                [R]
                     ♦  R_CINTR        =  Rc,                   [R]
                     ♦  L_TUBE_P1      =  l_tube_p1 ,           [R]
                     ◊  L_TUBE_P2      =  / l_tube_p2,          [R]
                                          / 0. ,                [DEFECT]
                     ◊  NB_ELEM_EPAIS=    /  nbel,              [I]
                                          /  3,                 [DEFECT]
                     ◊  SYME           =  /  'QUARTER' ,        [TXM]
                                          /  'HALF'    ,        [TXM]
                                          /  'WHOLE'   ,        [DEFECT]
                     ◊  TRANSFORM =   /   'TUBE'    ,         [TXM]
                                          /  'ELBOW'   ,        [DEFECT]

# So TRANSFORMED = 'ELBOW'
                     ♦  DEXT       =  Of ,                      [R]
                     ♦  THICK      =  E  ,                      [R]
                     ◊  SUR_EPAIS =   / surep,                  [R]
                                      / 0. ,                    [DEFECT]
                     ◊  BOL_P2     =  /   'ASP_MPP' ,           [TXM]
                                      /   'TANK'    ,
# Finsi
```

```
# So TRANSFORMED = 'TUBE'
                      ◊   TRAN_EPAIS    =  / 'NOT',                [DEFECT]
                                           / 'YES',                [TXM]

#       If TRAN_EPAIS = 'YES'

                          ♦   DEXT_T1    =  De_t1  ,            [R]
                          ♦   EPAIS_T1   =  e_t1   ,            [R]
                          ♦   EPAIS_T2   =  e_t2   ,            [R]
                          ♦   ANGL_TETA1=  teta1  ,            [R]
                          ◊   ANGL_TETA2=  teta2  ,            [R]
                          ◊   EPAIS_TI   =  e_ti   ,            [R]
                          ♦   / ABSC_CURV_TRAN =  ltran  ,      [R]
                              / POSI_ANGU_TRAN =  phi    ,      [R]

#       Finsi


#       If TRAN_EPAIS = 'NOT'

                          ♦   DEXT       =  Of  ,                 [R]
                          ♦   THICK      =  E   ,                 [R]
                          ◊   SUR_EPAIS =  / surep,               [R]
                                           / 0. ,                 [DEFECT]
                          ◊   BOL_P2     =  /  'ASP_MPP' ,        [TXM]
                                           /  'TANK'    ,

#       Finsi

# Finsi

                          )

    ◊/SOUS_EPAIS_COUDE =_F (   ♦   TYPE   =   /   'ELLI',
                                              ♦  AXE_CIRC   =  2a, [R]
                                          /   'AXIS',
                               ♦   AXE_LONGI          =  2b  ,     [R]
                               ♦   DEPTH        =  C   ,       [R]
                               ♦   / POSI_CURV_LONGI   =  sl  ,     [R]
                                  / POSI_ANGUL         =  beta,     [R]
                               ♦   / POSI_CURV_CIRC    =  Sc  ,     [R]
                                  / AZIMUTH            =  phi ,     [R]
                               ♦   SOUS_EPAIS          =/'INTERN',  [TXM]
                                                        /'EXTERNAL',
                               ♦   NB_ELEM_LONGI       =  nl  ,     [I]
                               ♦   NB_ELEM_CIRC        =  nc  ,     [I]
                               ◊   PRINT            =  / 'NOT',  [TXM]
                                                      / 'YES',  [DEFECT]
                               ◊   NB_ELEM_RADI        =  / NR   ,  [I]
                                                      / 3    ,  [DEFECT]
                            )
```

```
      / SOUS_EPAIS_MULTI =_F ( ♦  TYPE   =  /  'ELLI',
                                              ♦  AXE_CIRC = 2a,   [R]
                                           /  'AXIS',
                               ♦  AXE_LONGI          =  2b ,      [R]
                               ♦  DEPTH        =  C   ,      [R]
                               ♦  / POSI_CURV_LONGI   =  sl ,      [R]
                                  / POSI_ANGUL        =  beta,     [R]
                               ♦  / POSI_CURV_CIRC    =  Sc ,      [R]
                                  / AZIMUTH           =  phi ,     [R]
                               ♦ SOUS_EPAIS           =  / 'INTERN',  [TXM]
                                                         / 'EXTERNAL',
                               ♦ NB_ELEM_LONGI        =  nl ,      [I]
                               ♦ NB_ELEM_CIRC         =  nc ,      [I]
                               ◊ PRINT             =  / 'NOT',  [TXM]
                                                      / 'YES',  [DEFECT]
                             )

        / FISS_COUDE =_F (  ♦  DEPTH  =  has,              [R]
                            ◊  AXIS          =  / 'YES',
                                                / 'NOT',             [DEFECT]

   # If AXIS = 'NOT'
                            ♦  LENGTH    =  2c ,               [R]
   # Finsi

                            ♦  / ABSC_CURV   =  sf     ,             [R]
                                / POSI_ANGUL=  beta   ,             [R]
                            ◊  AZIMUTH       =  / phi  ,             [R]
                                                / 90.  ,             [DEFECT]
                            ♦  ORIEN         =  / xsi  ,             [R]
                                                / +45. ,
                                                / -45. ,
                                                /  90. ,
                                                /   0. ,
                            ♦  CRACK     =  / 'DEB_INT',       [TXM]
                                                / 'DEB_EXT',
                            ♦  NB_TRANCHE    =  NT  ,                [I]

                            ♦  NB_SECTEUR    =  NS  ,                [I]
                            ♦  NB_COURONNE   =  nc  ,                [I]
                            ◊  RAYON_TORE    =  rc0 ,                [R]
                            ◊  COEF_MULT_RC2 =  / rc2  ,             [R]
                                                / 1.   ,             [DEFECT]
                            ◊  COEF_MULT_RC3 =  rc3    ,             [R]
                            ◊  ANGL_OUVERTURE   =  / eps  ,          [R]
                                                   / 0.5  ,          [DEFECT]
                         )
```

```
    ◊  =_F IMPRESSION ( ◊  FILE   =  nom_fichier  ,           [TXM]
                        ◊  UNIT      =  unit         ,            [I]
                        ◊  /  FORMAT    =  /  'ASTER',            [DEFECT]
                           /  FORMAT    =  /  'IDEAS',
                               ◊ VERSION   =  / 4,                [I]
                                              / 5,                [DEFECT]
                           /  FORMAT    =  'CASTEM'  ,
                               ◊ NIVE_GIBI =  /  3   ,            [I]
                                              / 10   ,            [DEFECT]
                      )

    ◊  INFORMATION      =  /1  ,
    [DEFECT]
                      /2  ,

)
```

3 Geometrical definition of the elbow

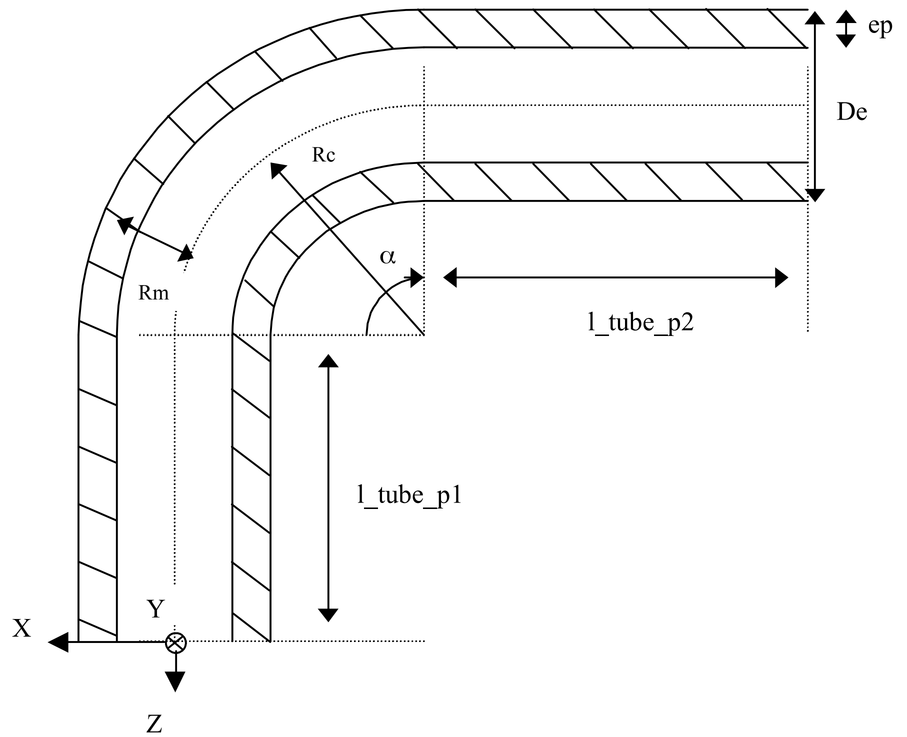


Figure 3-a: Description of the various geometrical parameters of the elbow

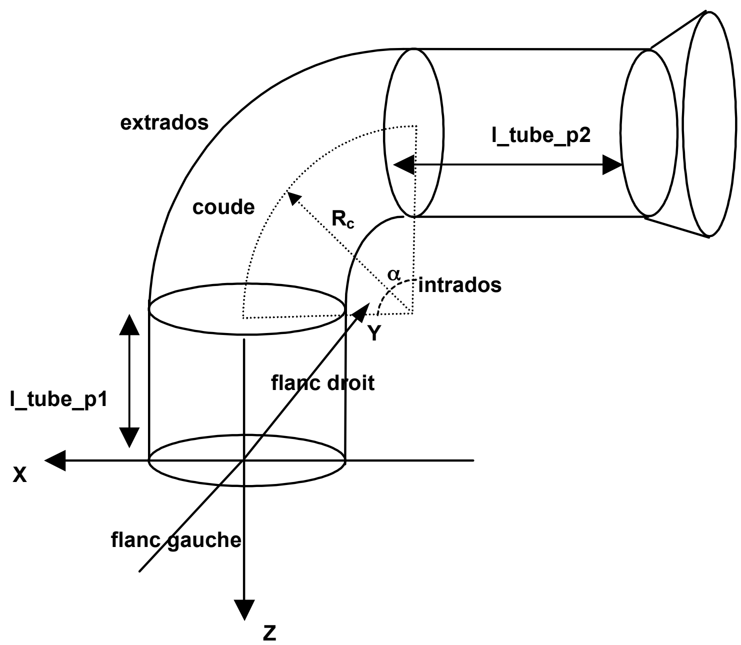


Figure 3-b: Sight 3D of the elbow and its ends

4 Operands

4.1 Keyword factor EXEC_MAILLAGE

4.1.1 Operand SOFTWARE

```
♦   SOFTWARE  =  /  'GIBI2000',  [DEFECT]
                 /  'GIBI98'  ,
```

Version of software GIBI carried out for the realization of the grid of the structure.

```
◊   UNITE_DATG   = unit_d
```

Logical number of unit where data GIBI making it possible are written to generate the grid of plate. The value by default is 70.

```
◊   UNITE_MGIB   = unit_s
```

Logical number of unit where the grid of plate to format GIBI is written. This grid is generated by GIBI. The value by default is 19.

```
◊   NIVE_GIBI    =  /  3,                    [I]
                    /  4,
                    /  5,
                    /  6,
                    /  7,
                    /  8,
                    /  9,
                    / 10,                    [DEFECT]
                    / 11,
```

Level of the software GIBI in which the grid is generated.

4.2 Operand TYPE_ELEM

Allows to choose the type of element (linear or quadratic) which will constitute the grid.

```
◊   TYPE_ELEM =  /  'CU20' ,                 [DEFECT]
                 /  'CUB8' ,                 [TXM]
```

4.3 Keyword factor ELBOW

4.3.1 Operand ANGLE

```
♦   ANGLE  = alpha
```

Value of the angle of the elbow in degrees. If one wishes to model only one tube without bending it (by using the option 'TUBE' operand TRANSFORM), the length of this one in its part "elbow" will be $\alpha \frac{\pi}{180} Rc$ where Rc is the ray of bending (see operand R_CINTR). It is thus necessary to choose α and Rc in such a way that the part "elbow" has the desired length. Values of α authorized lie between 20 and 90 degrees.

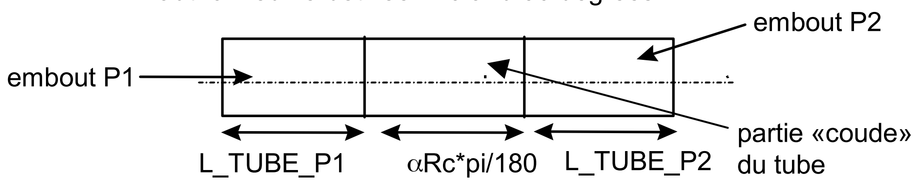


Figure 4.3.1-a: longitudinal distances from the structure

4.3.2 Operand **R_CINTR**

♦ `R_CINTR = Rc`

Value of the ray of bending of the elbow. The ray of bending must be such as: $Rc \leqslant De/2$.

4.3.3 Operand **L_TUBE_P1**

♦ `L_TUBE_P1 = l_tube_p1`

Value length of the P1 end at the end of which the loadings will be applied. The length of this end must be higher than the length of damping of the wave of inflection being propagated since the part bends and being worth $L_{amor}=\frac{3}{2}\sqrt{\frac{R_m^3}{e}}$. If this dimension is not reached for the end a message of alarm not blocking is transmitted.

4.3.4 Operand **L_TUBE_P2**

◊ `L_TUBE_P2 = l_tube_p2`

Value length of the P2 end at the end of which the boundary conditions will be applied. The length of this end must be higher than the length of damping of the wave of inflection being propagated since the part bends and being worth $L_{amor}=\frac{3}{2}\sqrt{\frac{R_m^3}{e}}$. If this dimension is not reached for the end a message of alarm not blocking is transmitted (except in the event of presence of a bowl).

4.3.5 Operand **SUR_EPAIS**

◊ `SUR_EPAIS = surep`

Value of the extra thickness presents in internal skin to the under-surface of the elbow. It is distributed thus on the elbow:

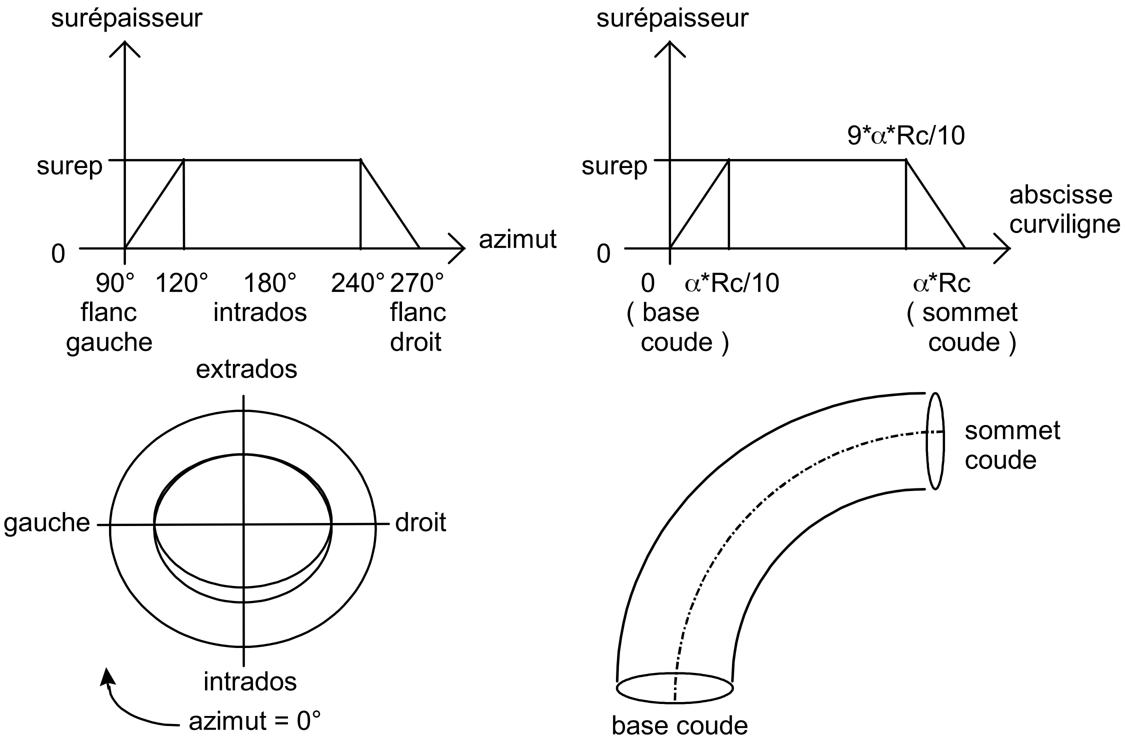


Figure 4.3.5-a: Extra thickness

Note:

It is possible to generate the grid of elbows or tubes comprising simultaneously one or more under - thickness and an extra thickness.

4.3.6 Operand BOL_P2

◊ BOL_P2

Allows to prolong the cylindrical end length l_tube_p2 by a bowl [bib1] to which one applies the boundary conditions. The possibilities are:

'TANK' bowl of type pipe of entry of tank,
'ASP_MPP' bowl of type pipe of primary aspiration of pump,

Caution:

This option is not valid for the elbows or tubes with under-thicknesses.

4.3.7 Operand NB_ELEM_EPAIS

◊ NB_ELEM_EPAIS= nbel

Allows to give the number of layers of elements present in the thickness of the elbow and of its ends.

Caution:

This option is not valid for the elbows or tubes with crack (keyword factor FISS_COUDE) or with a under-thickness (keyword factor SOUS_EPAIS_COUDE). The number of elements in the thickness of the elbow part is then fixed at three (except the zone of the defect which presents a specific refinement) and at for the zones ends.

4.3.8 Operand SYME

```
◊ SYME = / 'QUARTER' ,
         / 'HALF'    ,
         / 'WHOLE'   ,          [DEFECT]
```

Allows to net all the structure or only one quarter or a half-structure and to thus treat elbows presenting of symmetries. The geometry represented is then the following one:

- for SYME=' DEMI' : the part of structure going of the median section of the elbow (forming the transverse symmetry plane) at the end of the P1 end,
- for SYME=' QUART' : the representation of the quarter of structure is made on the same support but for a value of angle $\theta \in [\Phi, \Phi+\pi]$ starting from the azimuth position Φ center of the defect. The tubular structure is then not closed and presents a longitudinal symmetry plane represented by two free edges.

  Example for the quarter of structure: if the defect is in azimuth 90° (located left side) then the sector of the quarter of structure modelled is located between left side and right side via the under-surface.

Here an illustration of the representation on the structure developed on a plate:

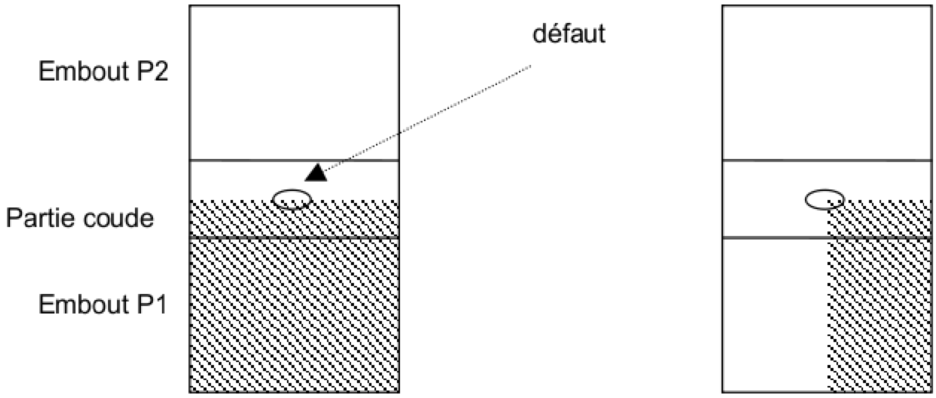


Figure 4.3.8-a: Representation of half and quarter of structure

Caution:

This option is valid only for the elbows or tubes comprising a defect.
The use of this operand requires four essential conditions:

1. *One and only one defect are modelled.*
2. *This one is placed on the median section of the elbow.*
3. *If it is about a crack, this one must be directed circonférentiellement. Moreover the elbow does not have to comprise of zone of transition from thickness.*
4. *The lengths of each end must be given equal.*

Calculations with the grid thus produced could not be realized with the macro ordering of calculation `MACR_ASCOUF_CALC` insofar as the P2 end does not exist: in a general way loadings of the standard basic effect related to internal pressure, moment and effort in P2 cannot be applied. One will refer to the paragraphs [§5.3] and [§5.4] for details on the conditions of symmetry to apply.

4.3.9 Operand TRANSFORM

◊ TRANSFORM

Allows to choose the type of transformation applied to the grid resulting from the procedure gibi carried out by the macro-order (see order MODI_MAILLAGE).

◊ TRANSFORM = / 'TUBE', transformation into tube,
/ 'ELBOW', transformation into elbow.

4.3.10 Operand TRAN_EPAIS

♦ `TRAN_EPAIS = / 'YES',`
`/ 'NOT',` [DEFECT]

Optional keyword indicating the presence or not transition from thickness.

The transitions from thickness relate to only the tubes **RIGHTS**. The internal ray remains constant and only the external ray varies. These transitions can be with one or two slopes. For these two types of transition, a defect must be present. The defect is either a circumferential crack, or a under-thickness which can emerge in external skin or internal skin. The defect is always perpendicular to the longitudinal axis of the right pipe. The crack or under-thickness can be axisymmetric. The site of the defect must be imposed so that it is located between the interface: P1 end/zone length αR_c (α in radian) and the beginning of the transition from thickness. In all the grid, the number of elements in the thickness remains identical.

The transition from thickness should not be entirely understood in the block of incrustation of the crack, including the block fissures and the zones of déraffinement to be connected to the regulated grid of the plate. In the event of transition to two slopes, it can include the first but in no case the totality of the transition.

In order to have lines of the grid confused with the beginning, the end (and possibly the break of slope) of the transition, the zone length αR_c and the P2 end are dissociated in several parts to which homotheties are applied. In the case fissured, if the transition from thickness begins in the block from incrustation, this one is not modified (except if the transition begins outside the block fissures) and the beginning of the transition from thickness is not in this not positioned case in an exact and rectilinear way.

Longitudinal size of the elements in the zone length αR_c can vary in a rather important way following homotheties. It is in this case advised to modify the value of and to recompute the value of R_c so that the length αR_c remain unchanged while modifying the longitudinal cutting of this zone. It is thus possible to change the longitudinal size of the elements of the plate which decreases when increase. The limits of the transition from thickness then are lucky more to coincide or to approach the initial position of the nodes to the grid.

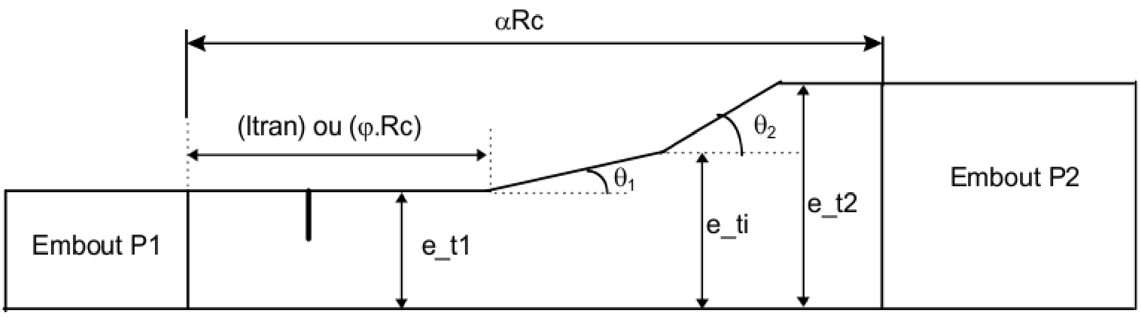


Figure 4.3.10-a: Cut thickness of the tube with transition from thickness to two slopes

4.3.11 Operand DEXT

♦ `DEXT = Of`

Obligatory keyword if there is no transition from thickness. Value of the external diameter of the elbow and the right ends.

4.3.12 Operand **THICK**

♦ `THICK = E`

Obligatory keyword if there is no transition from thickness. Value thickness of the elbow and the ends.

Note:

beaches of use for this parameter are different according to the type of defect considered:
1) *pricking with a single under-thickness: the report* `Rm/e` *must be ranging between 5 and 50, where Rm indicates the average radius;*
2) *pricking fissured or with under-thicknesses multiple: the report* `Rm/e` *must be ranging between 5 and 21.*

In this last case, it is possible to generate a grid for reports going up to 50. An alarm is however emitted to announce that the quality of the grid obtained is not guaranteed (possibility of too stretched meshs,…).

4.3.13 Operand **DEXT_T1**

♦ `DEXT_T1 = De_t1`

Obligatory operand if there is a transition from thickness. Value of the external diameter of the elbow before the transition from thickness. It must respect 112 mm `De_t1` 880 mm if the transition from thickness is with a slope and 77 mm `De_t1` 355 mm if the transition from thickness is with two slopes.

4.3.14 Operand **EPAIS_T1**

♦ `EPAIS_T1 = e_t1`

Obligatory operand if there is a transition from thickness. Value thickness of the elbow before the transition from thickness. It must respect $12\,mm \le e_{t1} \le 80\,mm$ if the transition from thickness is with a slope and $7\,mm \le e_{t1} \le 35\,mm$ if the transition from thickness is with two slopes.

4.3.15 Operand **EPAIS_T2**

♦ `EPAIS_T2 = e_t2`

Obligatory operand if there is a transition from thickness. Value thickness of the elbow after the transition from thickness. It must respect $20\,mm \le e_{t2} \le 110\,mm$ if the transition from thickness is with a slope and $15\,mm \le e_{t2} \le 40\,mm$ if the transition from thickness is with two slopes.

4.3.16 Operand **ANGL_TETA1**

♦ `ANGL_TETA1 = teta1`

Obligatory operand if there is a transition from thickness. Value of the angle of inclination of the transition from thickness (first slope if there are two of them). It must respect $0° \le teta1 \le 30°$.

4.3.17 Operand **ANGL_TETA2**

♦ `ANGL_TETA2 = teta2`

Operand optional, indicating if it is present a transition from thickness at two slopes. Value of the angle of inclination of the second slope of the transition from thickness. It must respect $0° \le teta2 \le 45°$.

4.3.18 Operand EPAIS_TI

◊ `EPAIS_TI = e_ti`

Obligatory operand if there is a transition from thickness to two slopes. Value thickness of the intermediate elbow during the break of slope. It must respect $15\,mm \le e_{ti} \le 40\,mm$ and $e_{t1} \le e_{ti} \le e_{t2}$.

4.3.19 Operands ABSC_CURV_TRAN and POSI_ANGU_TRAN

♦ `/ ABSC_CURV_TRAN = ltran`
`/ POSI_ANGU_TRAN = phi`

One (and only one) of these operands are obligatory if there is a transition from thickness. Value of the longitudinal position of the beginning of the transition from thickness given respectively by the curvilinear X-coordinate or the angular position, counted positively starting from the interface with the P1 end. The curvilinear X-coordinate is defined along the axis of the elbow on the external skin of this one, and one has then `ltran` = ΦR_c .

If the defect is a circumferential crack located at a curvilinear distance `sf` interface with the P1 end, `ltran` or Φ must respect: $0 \le sf \le \mathrm{ltran} \le \alpha R_c$.

If the defect is a under-thickness whose center is located at a distance `sf` interface with the P1 end and of which the width (`AXE_LONGI`) is worth `2b`, `ltran` or Φ must respect:
$0 \le sf + b \le \mathrm{ltran} \le \alpha R_c$.

4.4 Keyword factor SOUS_EPAIS_COUDE or SOUS_EPAIS_MULTI

These two keyword factor make it possible to model an elbow or a tube comprising only one under-thickness (keyword `SOUS_EPAIS_COUDE`) thanks to a procedure of grid equipped with déraffinement automatic, or to model one or more under-thicknesses (keyword `SOUS_EPAIS_MULTI`) by a procedure of uniformly regulated grid. The keyword is repeated `SOUS_EPAIS_MULTI` for each under-thickness to be defined.

4.4.1 Operand TYPE

♦ `TYPE`

Allows to define the type of under-thickness to be modelled:

`'ELLI'` : under thickness of the elliptic type defined by its axes circumferential and longitudinal.
`'AXIS'` : under axisymmetric thickness defined by its longitudinal axis.

4.4.2 Operand AXE_CIRC

♦ `AXE_CIRC = 2a`

Length of the circumferential axis under-thickness measured in curvilinear X-coordinate in external skin on the elbow, even if the under-thickness is located in internal skin. Is used only if `TYPE = 'ELLI'`.

4.4.3 Operand AXE_LONGI

♦ `AXE_LONGI = 2b`

Length of the longitudinal axis under-thickness measured in curvilinear X-coordinate in external skin on the elbow, even if the under-thickness is located in internal skin.

4.4.4 Operand DEPTH

♦ `DEPTH = C`

Value maximum depth measured in the center under-thickness.

4.4.5 Operands POSI_CURV_LONGI and POSI_ANGUL

♦ `/ POSI_CURV_LONGI = sl`
`/ POSI_ANGUL = beta`

Value of the longitudinal position of the center under-thickness, definite compared to the interface of the P1 end. The position can be given either by the curvilinear X-coordinate `sl` the lonG of the axis of the elbow on the external skin of this one, is by the angle `beta` in degrees formed by the section containing this one and interfaces it P1 end.

This value must be ranging between 0 and αR_c (for `sl`) or 0 and α (for `beta`).

4.4.6 Operands POSI_CURV_CIRC and AZIMUTH

♦ `/ POSI_CURV_CIRC = Sc`
`/ AZIMUTH = phi`

Value of the circumferential position of the center under-thickness given is by the curvilinear X-coordinate `Sc` on the external skin of this one, that is to say by the angle in degrees `phi`. The angle and the curvilinear X-coordinate are counted positively starting from the suction face to the under-surface via the left side. This value must be ranging between 0 and πD_e (for `Sc`) or between 0 and 360 degrees (for `phi`).

If under-thickness is of the axisymmetric type, the center by convention is positioned under-surface (180 °) and must be indicated like tel.

4.4.7 Operand SOUS_EPAIS

♦ `SOUS_EPAIS`

Allows to define the position under-thickness on the skin of the elbow:

`'INTERN'` under-thickness in skin interns elbow,
`'EXTERNAL'` under-thickness in external skin of the elbow.

4.4.8 Operand NB_ELEM_LONGI

♦ `NB_ELEM_LONGI= nl`

Allows to define the number of elements present on the longitudinal axis under-thickness.

Note:

•The stage of treatment of the macro-order which transforms successively the initial grid of plate into elbow with for effect to compress the meshs longitudinally zones under-surface of them and to dilate them in zone suction face. In the event of defect positioned in these zones, the number of elements defined on the longitudinal axis (which is used to create the initial grid of plate) will be able to be seen slightly reduced or increased. Thus for an axisymmetric under-thickness, the number of elements present longitudinally can vary from two units on an elbow with 90°. Generally, one will advise with the user sufficiently to discretize the axes of the defect. The elliptic profile under-thickness will be only better.

•The case of a defect located at horse between elbow and end can cause a representation the under-thickness which is not perfectly symmetrical in the longitudinal direction. This is due to the same phenomenon as previously added to the fact that the part the under-thickness presents in the end does not undergo geometrical transformation. There still, one can advise with the user to refine the longitudinal axis to correct this light dissymmetry.

4.4.9 Operand NB_ELEM_CIRC

♦ `NB_ELEM_CIRC = nc`

Allows to define the number of elements present on the circumferential axis under-thickness.

Note:

***ATTENTION with coherence** between the circumferential number of elements, the longitudinal number of elements and geometry under-thickness. In particular, when this one is circumferential, the circumferential number of elements must be about 20.*

4.4.10 Operand PRINT

◊ `PRINT =`
`/ 'YES',` `[DEFECT]`

The under-thickness is dug: the points belonging to the half-ellipsoid defining under - thickness undergo a geometrical transformation proportional in the thickness.

`/ 'NOT',`

The under-thickness is not dug: the geometrical transformation of the points defining it is not activated. The grid does not comprise a under-thickness.

4.4.11 Operand NB_ELEM_RADI

◊ `NB_ELEM_RADI = NR`

Allows to radially define the number of elements present (in the direction thickness of the elbow) towards the under-thickened zone. By default, this value is of three as for the current part of the elbow.

Caution:

This option is valid only for the keyword `SOUS_EPAIS_COUDE` (single under-thickness).

4.5 Keyword factor FISS_COUDE

Three cases are possible to distinguish the short cracks and the long cracks. The distinction is done according to the report has_p/c_p (has_p being depth and C_p the half-length of the crack on the plate before transformation into tube or elbow):

- the cracks are short elliptic if $a_p/c_p \geq 0.2$,
- the cracks are long with the rectilinear bottom and the round ends if $0.1 \leq a_p/c_p < 0.2$ or if the orientation is longitudinal,
- the cracks are long with the rectilinear bottom if $a_p/c_p < 0.1$ and if the orientation is circumferential (it is the case in particular for the axisymmetric cracks).

4.5.1 Operand DEPTH

♦ DEPTH = has

Half length of the small axis of the crack.

4.5.2 Operand LENGTH

♦ LENGTH = 2c

Length of the main roads of the crack measured on the elbow in internal or external skin according to the skin on which the crack is. This length is obligatory if the crack is not axisymmetric. She is on the other hand ignored if she is provided and that the crack is axisymmetric.

4.5.3 Operand AXIS

```
◊ AXIS = / 'YES',
         / 'NOT',              [DEFECT]
```

Optional keyword indicating if the crack is axisymmetric or not.

4.5.4 Operand AZIMUTH

◊ AZIMUTH = phi

Value of the circumferential position of the center of the crack counted positively in degrees starting from the suction face to the under-surface via the left side. The definite position by default is on the left side (azimuth equal to 90 degrees). The azimuth must be understood between 0° and 180°.

4.5.5 Operands ABSC_CURV and POSI_ANGUL

```
♦ / ABSC_CURV  = sf
  / POSI_ANGUL = beta
```

Value of the longitudinal position of the center of the crack, definite compared to the interface of the P1 end. The position can be given either by the curvilinear X-coordinate sf along the axis of the elbow on the internal or external skin (according to the position of the crack), that is to say by the angle beta in degrees formed by the section containing this one and interfaces it P1 end.

This value must be understood:

- for sf : between 0 and $\alpha\left[Rc+(Rm+\eta e/2)\cos(\phi)\right]$, where η 1 is worth if the defect is in external skin and – 1 if not;

- for beta : between 0 and α .

4.5.6 Operand ORIEN

♦ ORIEN = xsi

Value of the angle in degrees formed by the main roads of the crack and the generator of the elbow giving the orientation of the defect thus.

Caution:

Only three types of orientation are possible:
- *longitudinal crack (xsi = 0 degree),*
- *circumferential crack (xsi = + 90 degrees),*
- *tilted crack (xsi = +45 or -45 degrees), only for the short cracks.*

A longitudinal crack cannot encroach on one of the two right ends, or the two right ends at the same time. On the other hand, the block fissures can it. In other words, the crack must inevitably be in the elbow, the block crack can overflow on the right ends.

4.5.7 Operand CRACK

♦ CRACK

Allows to define the position of the crack on the skin of the elbow:

'DEB_INT' crack emerging in skin interns elbow,
'DEB_EXT' crack emerging in external skin of the elbow.

4.5.8 Operand NB_TRANCHE

♦ NB_TRANCHE = NT

For the short cracks, many slices along the bottom of crack **on a quarter of ellipse**. The total number of slices is then this data multiplied by two (see [Figure 4.5.9-a]). This value must be a power of 2 and must be worth 8 at least.

For the long cracks with round ends, NT is the number **total** slices, ranging between 20 and 186 on the totality of the bottom of crack, with 8 slices for each round end and between 4 and 170 slices on the rectilinear part.

For the long cracks at rectilinear bottom only, the number of slices must be ranging between 8 and 40.

In the case of the circumferential cracks, the following table provides a reasonable estimate amongst slices for the rectilinear part of the long cracks according to the report $2c/2\pi R_m$ (length of the crack over width of the plate) for two levels of refinement. For the long cracks with round ends, it is thus necessary to add 16 slices.

$c/\pi R_m$>	0	0.02	0.04	0.06	0.08	0.1	0.12	0.14	0.16	0.18	0.2	0.22	0.24	0.26	0.28	0.32	0.34	0.36
$c/\pi R_m$<	0.02	0.04	0.06	0.08	0.1	0.12	0.14	0.16	0.18	0.2	0.22	0.24	0.26	0.28	0.32	0.34	0.36	1
NT end	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	40
NT large	4	4	6	6	8	8	10	10	12	12	14	14	16	16	18	18	20	20

In the case as of longitudinal cracks or of the cracks having a report a/c such as $0.1 \leqslant a/c < 0.2$, the number of slices can vary between 20 and 186. included. One needs a report of stretching of the meshs from approximately 10 (large side/small side), a report of stretching of about 20 being acceptable.

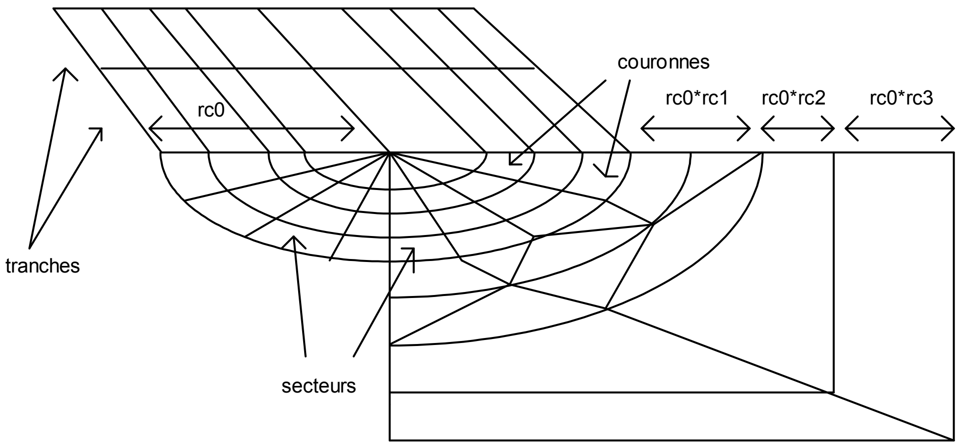


Figure 4.5.9-a: Parameters of the basic grid radiating of crack

4.5.9 Operand NB_SECTEUR

♦ `NB_SECTEUR = NS`

Many sectors on 90 degrees in a crown of the torus modelling the bottom of crack. The full number of sectors on a crown is then this data multiplied by four (see [Figure 4.5.9-a]).

For the long cracks, this value must be worth 2.3 or 4. For the other types of crack this value should not exceed 8.

4.5.10 Operand NB_COURONNE

♦ `NB_COURONNE = nc`

Many crowns of the grid radiating around the bottom of crack, including the formed central crown by prisms (see [Figure 4.5.9-a]).

For the long cracks, this value must be worth 3 or 4.

4.5.11 Operand RAYON_TORE

◊ `RAYON_TORE = rc0`

Allows to define the value of the ray of the torus of the zone in imposed grid of type radiating around the bottom of crack (see [Figure 4.5.9-a]). Are a depth of the crack and e the thickness of the pipe, by default, the ray is worth:

$rc_0 = \frac{rc_0^{ref}}{0.2} \frac{a}{e}$ where $rc_0^{ref} = 2\,mm$ if the number of slices is equal to or higher than 16,

$rc_0 = 1,5\,mm$ if not.

4.5.12 Operand COEF_MULT_RC2

◊ COEF_MULT_RC2 = rc2

Value of the multiplying coefficient of rc0 allowing to define the thickness of the first crown of déraffinement of the slices (see [Figure 4.5.9-a]). By default this coefficient is worth 1.

4.5.13 Operand COEF_MULT_RC3

◊ COEF_MULT_RC3 = rc3

Value of the multiplying coefficient of rc0 allowing to define the thickness of the second crown of déraffinement of the slices (see [Figure 4.5.9-a]). By default, this coefficient is worth 1 if the number of slices is lower than 16 and 1.4 if not.

4.5.14 Operand ANGL_OUVERTURE

◊ ANGL_OUVERTURE = eps

Value in degrees of the half angle of opening of the crack. By default, eps 0.5 are worth.

4.6 Keyword factor IMPRESSION

4.6.1 Operand FILE

◊ FILE = nom_fichier

Name given to the print file. By default, the print file is the file of the standard grid Aster (.mast). It is thus important to put this kind of file in the profile of study if one uses the options by default of the keyword IMPRESSION.

4.6.2 Operand UNIT

◊ UNIT = unit

Logical number of unit associated with the print file.

4.6.3 Operand FORMAT

◊ FORMAT

Allows to specify the format of impression of the grid. By default the format is 'ASTER'.

4.6.4 Operand VERSION

◊ VERSION

If and only if the operand FORMAT is worth 'IDEAS', this operand makes it possible to specify the version of the Ideas software. By default VERSION is worth 5. Only versions 4 and 5 are supported.

4.6.5 Operand NIVE_GIBI

◊ NIVE_GIBI

If and only if the operand FORMAT is worth 'CASTEM', this operand makes it possible to specify the level of the software GIBI in which the grid will be printed. By default VERSION is worth 10. Only levels 3 and 10 are supported.

4.7 Operand INFORMATION

◊ INFORMATION =

Indicate the level of impression of the results of the operator,

1: no impression,
2: impression of the relative information to the grid.

The impressions are done in the file 'MESSAGE'.

To have the detail of the operators called by the macro-order in the file message, it is necessary to specify IMPR_MACRO=' OUI' in the order BEGINNING.

5 Topological grid and groups

5.1 Grid of plate

The grid of plate 3D produced by the procedure of grid GIBI before geometrical transformation into tube or elbow is defined as follows:

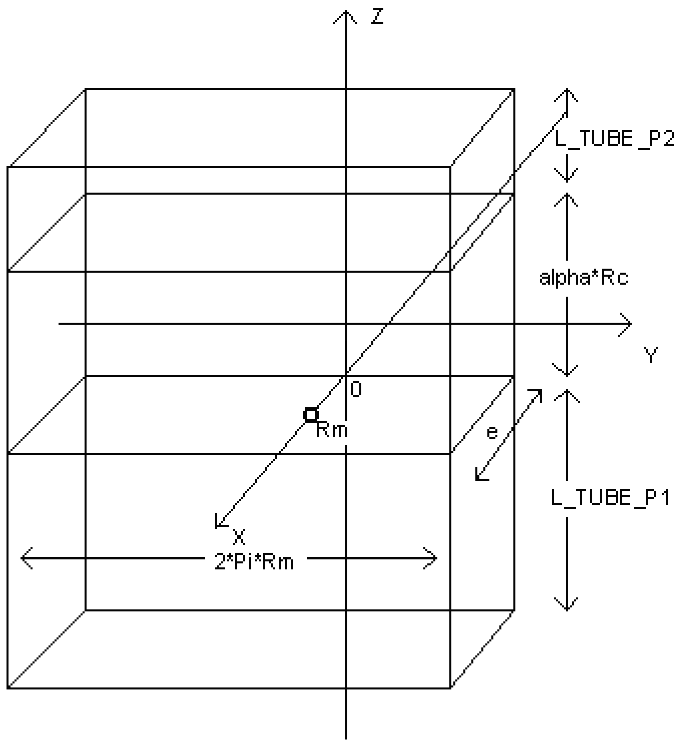


Plate generated by procedure GIBI

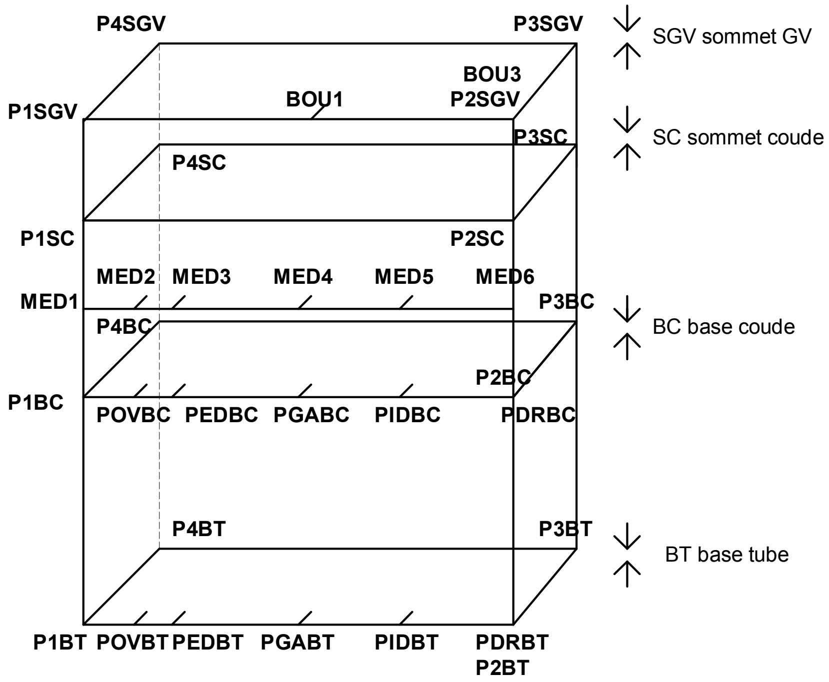
R_m	: average radius,
alpha	: angle of the elbow in radians,
E	: thickness,
R_C	: ray of bending,
L_TUBE_P1	: length of the P1 end,
L_TUBE_P2	: length of the P2 end.

The reference mark of the grid plate is at the base of the part bends (interface between the zone bends and the P1 end), the plate occupies the following fields: $X\in[R_m-e/2, R_m+e/2]$, $Y\in[-\pi*R_m, \pi*R_m]$, $Z\in[-\mathrm{L\_TUBE\_P1}, \alpha*R_c+\mathrm{L\_TUBE\_P2}]$.

The macro order `MACR_ASCOUF_MAIL` generate the following grids according to the desired geometry (healthy elbow, elbow with crack, elbow with under-thicknesses):

5.2 Regulated healthy elbow

The grid thus carried out comprises the following geometrical groups (the fields are given in the reference mark grid plates):



Geometrical groups of the healthy elbow regulated before transformation into elbow

- MED6: group of nodes made up of the node located in external skin on the right side more close to median section of the part bends ($X=R_m+e/2, Y=\pi*R_m, Z=\alpha*R_c/2$),
- MED5: group of nodes made up of the node located in external skin on the under-surface more close to the median section of the part bends ($X=R_m+e/2, Y=\pi*R_m/2, Z=\alpha*R_c/2$),
- MED4: group of nodes made up of the node located in external skin on the left side more close to the median section of the part bends ($X=R_m+e/2, Y=0, Z=\alpha*R_c/2$),
- MED3: group of nodes made up of the node located in external skin on the suction face more close to the median section of the part bends ($X=R_m+e/2, Y=-\pi*R_m/2, Z=\alpha*R_c/2$),
- MED2: group of nodes made up of the node located in external skin more close to the median section of the part bends ($X=R_m+e/2, Y=-4\pi*R_m/5, Z=\alpha*R_c/2$),
- MED1 (=MED6 on the elbow): group of nodes made up of the node located in external skin on the right side more close to the median section of the part bends ($X=R_m+e/2, Y=-\pi*Rm, Z=\alpha*Rc/2$).

-

Groups of points useful for the boundary conditions of type beam:

- BOU1: group of nodes made up of the node located in external skin on the left side at the top of the P2 end or the bowl ($X=R_m-e/2, Y=0, Z=\alpha*R_c+\text{l\_tube\_p2}+\text{longueur bol}$),
- BOU3: group of nodes made up of the node located in external skin on the right side at the top of the P2 end or the bowl ($X=R_m-e/2, Y=+\pi*R_m, Z=\alpha*R_c+\text{l\_tube\_p2}+\text{longueur bol}$),
- P1 : node located at the center section EXTUBE,
- P2 : node located at the center section CLGV.

Groups of points defining the generators of the elbow:

- LEFT: group of nodes constituting the whole of the nodes located in external skin on the left side of the elbow and the ends ($X=R_m+e/2$, $Y=0$),
- RIGHT: group of nodes constituting the whole of the nodes located in external skin on the right side of the elbow and the ends ($X=R_m+e/2$, $Y=-\pi*R_m$),
- INTRA: group of nodes constituting the whole of the nodes located in external skin on the under-surface of the elbow and the ends ($X=R_m+e/2$, $Y=+\pi*R_m/2$),
- EXTRA: group of nodes constituting the whole of the nodes located in external skin on the suction face of the elbow and the ends ($X=R_m+e/2$, $Y=-\pi*R_m/2$).

Group of linear meshs:

- BORDTU: contour interns section at the end of the P1 end ($Z=-\mathrm{l\_tube\_p1}$).

Group of surface meshs:

- PEAUEXT: external skin of the elbow and the ends ($X=R_m+e/2$),
- PEAUINT: skin interns elbow and ends ($X=R_m-e/2$),
- EXTUBE: section at the end of the P1 end (Z = - l_tube_p1),
- CLGV: section at the end of the P2 end ($Z=\alpha*R_c+\mathrm{l\_tube\_p2}$).

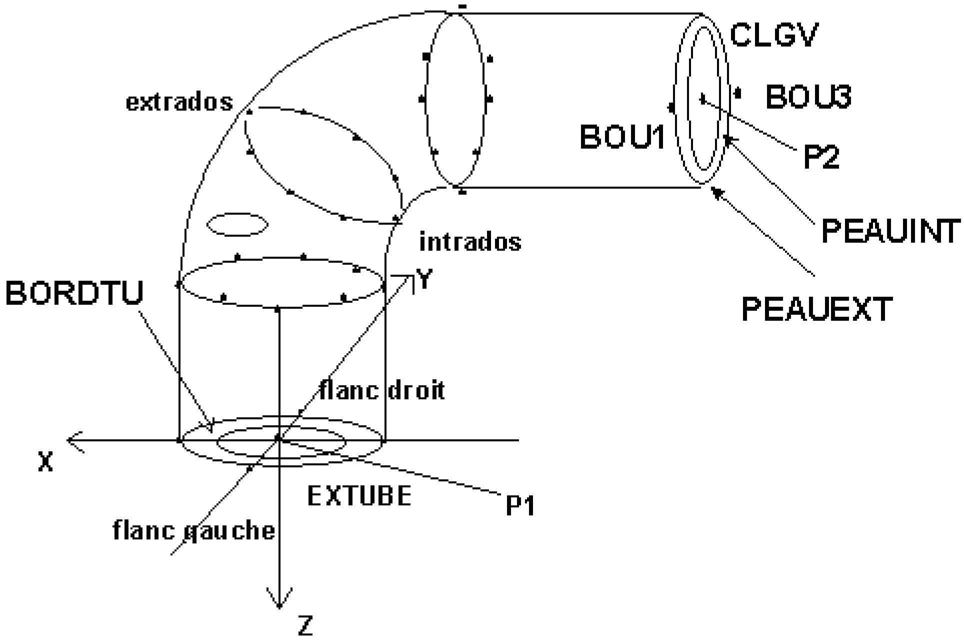
Très Important :

> *The elements of skin described above have an external outgoing normal in external skin and an outgoing normal interns in internal skin.*

Group of voluminal meshs:

- ELBOW: group of voluminal meshs constituting the elbow, the P1 end and the P2 end representing the part of the stainless structure made up,
- PACOUDE: group of voluminal meshs constituting the elbow ($0\leq Z\leq\alpha*Rc$),
- EMBOUTTU: group of voluminal meshs constituting the P1 end ($-\mathrm{l\_tube\_p1}\leq Z\leq 0$),
- EMBOUTGV: group of voluminal meshs constituting the P2 end ($\alpha*Rc\leq Z\leq\alpha*Rc+\mathrm{l\_tube\_p2}$),
- MY: group of meshs containing the whole of the voluminal and surface meshs definite, as well as the discrete meshs.

5.3 Elbow with under-thicknesses

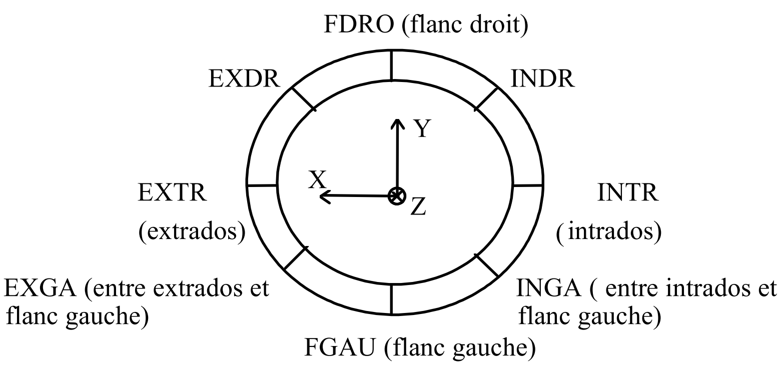


Elbow with under-thicknesses (ELBOW)

At the conclusion of the execution of the procedure, the grid will mention following topological entities in order to facilitate visualization, the application of the loadings, the assignment of the boundary conditions and the mechanical analysis:

- **ELBOW** : together voluminal elements of the grid bends and ends,
- **CLGV** : elements of membrane located at the end of the P2 end,
- **EXTUBE** : elements of membrane located at the end of the P1 end,
- **PEAUINT** : elements of membrane located in internal skin of the structure
- **PEAUEXT** elements of membrane located in external skin of the structure,
- **BOU1** : node located at the end of the P2 end in external skin and left side,
- **BOU3** : node diametrically opposed to BOU1 on the section of the tube, located at the end of the P2 end in external skin and right side,
- **P1** : node located at the center of section EXTUBE,
- **P2** : node located at the center of section CLGV,
- **BORDTU** contour interns section at the end of the P1 end (Z = 0).

Points BOU1 and BOU3 are located left side and right side for an azimuth of the defect $\Phi=90°$, they "turn" if this one is different. The eight groups of nodes formed by the ligaments in the thickness taken all the 45 degrees (or closest to these positions) on a section are prefixed in the following way:



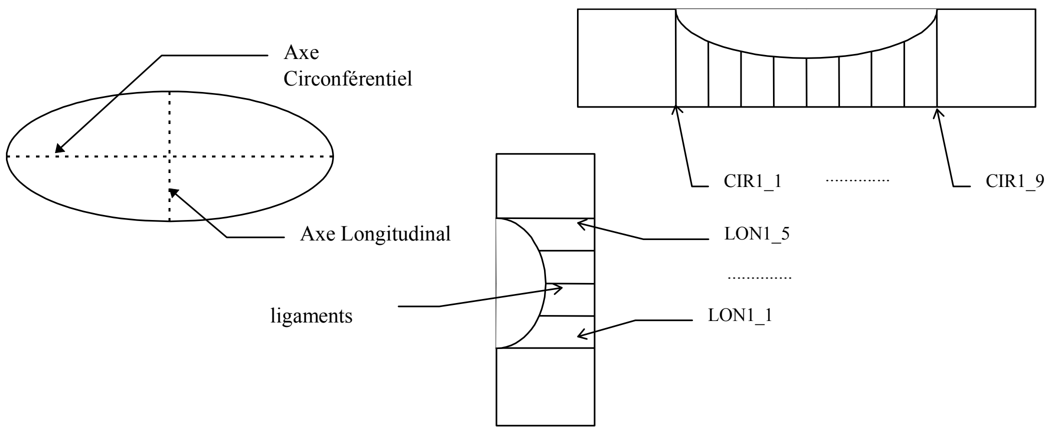
- **EXGAMI, FGAUMI, INGAMI, INTRMI, INDRMI, FDROMI, EXDRMI, EXTRMI** : groups of nodes formed by the ligaments in the thickness all 45 degrees on the median section of the elbow (or nearest).
- **EXGATU, FGAUTU, INGATU, INTRTU, INDRTU, FDROTU, EXDRTU, EXTRTU** : groups of nodes formed by the ligaments in the thickness all the 45 degrees on the section interfaces between the end tubes and the elbow.
- **EXGAGV, FGAUGV, INGAGV, INTRGV, INDRGV, FDROGV, EXDRGV, EXTRGV** : groups of nodes formed by the ligaments in the thickness all the 45 degrees on the section interfaces between the end Steam Generator and the elbow.
- **EXGA*X*, FGAU*X*, INGA*X*, INTR*X*, INDR*X*, FDRO*X*, EXDR*X*, EXTR*X*** : groups of nodes formed by the ligaments in the thickness all 45 degrees on the section corresponding to the minimal thickness the N°x under-thickness.

For the nonaxisymmetric under-thicknesses:

- **CIR*x_y*** : group of nodes representing the circumferential ligament n°y under-thickness n°x. The ligaments are sorted according to Y growing on the grid plates.
- **LON*x_z*** : group of nodes representing the longitudinal ligament n°z under-thickness n°x. The ligaments are sorted according to Z growing on the grid plates.
- **PCIRC*X*** : together nodes the N°x under-thickness located on the circumferential axis and at the right of this one on all the thickness,
- **PLONG*X*** : together nodes the N°x under-thickness located on the longitudinal axis and at the right of this one on all the thickness,
- **PCENT*X*** : together nodes the N°x under-thickness located at the center of the ellipse and the right of this one on all the thickness (intersection of the groups PLONGx and PCIRCx),

Important :

For each ligament, the nodes are ordered external skin with the internal skin.



5.3.1 Case of the half-structure

The following entities present but are associated with places different from the whole structure:

- **CLGV** : elements of membrane located in median section forming the transverse symmetry plane of the elbow,
- **BOU1** : node located on the median section in external skin on the left side for an azimuth of the defect of 90°,
- **BOU3** : node diametrically opposed to BOU1 on the median section, located in external skin on the right side,
- **P2** : node located at the center section CLGV.

Ligaments **EXGAGV, FGAUGV, INGAGV, INTRGV, INDRGV, FDROGV, EXDRGV, EXTRGV** do not exist.

The boundary conditions for a half-structure in order to block displacements of rigid body and to simulate the conditions of symmetry are the following ones (α is the angle of the elbow and Φ the azimuth of the defect):

- Blocking of normal displacement to the median section (CLGV):
  $DZ=0$ for a tube,
  $DNOR=0$ for an elbow.
- A point on the aforementioned section blocked in the plan of this one:
  $DX=DY=0$ for a tube,
  $DY=0$ $\cos(\alpha)DX-\sin(\alpha)DZ=0$ for an elbow.
- The symmetrically opposed point (located at the azimuth Φ_1) with the precedent in the section, blocked in tangent displacement with the aforementioned section:
  $\sin(\Phi_1)DX+\cos(\Phi_1)DY=0$ for a tube,
  $\sin(\Phi_1)\cos(\alpha)DX+\cos(\Phi_1)DY-\sin(\Phi_1)\sin(\alpha)DZ=0$ for an elbow.

Note:

One can also for the half-structure plan to preserve the principle of the connection 3D-beam (used with whole modeling in `MACR_ASCOUF_CALC`) with a node in the middle of the median section (in fact P2).

5.3.2 Case of the quarter of structure

The modifications are similar to the preceding paragraph. Moreover, the two edges forming the longitudinal symmetry plane of the elbow are available:

- **BORD1** : elements of membrane located left side for an azimuth of defect $\Phi=90°$,
- **BORD2** : elements of membrane located right side for an azimuth of defect $\Phi=90°$.

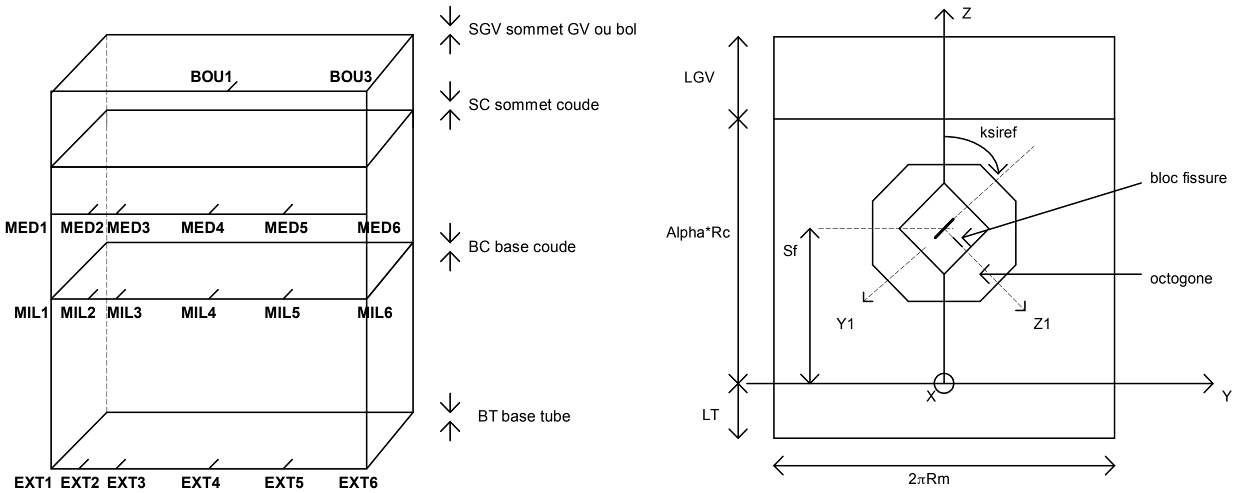
The boundary conditions for a quarter of structure in order to block displacements of rigid body and to simulate the conditions of symmetry are the following ones (α is the angle of the elbow and Φ the azimuth of the defect):

- Blocking of normal displacement to the median section (CLGV):
  $DZ=0$ for a tube,
  $DNOR=0$ for an elbow.
- Blocking of the longitudinal symmetry plane of the tubular structure:
  $DNOR=0$ on BORD1 and BORD2.

- Blocking of displacement perpendicular to the longitudinal symmetry plane of one of points (BOU3 to avoid taking the point located in the zone of the defect which is BOU1) located at the intersection of the two plans previously quoted:
  $\cos(\Phi)DX+\sin(\Phi)DY=0$ for a tube,
  $\cos(\Phi)\cos(\alpha)DX+\sin(\Phi)DY-\cos(\Phi)\sin(\alpha)DZ=0$ for an elbow.

5.4 Elbow with crack

The grid thus carried out comprises the following geometrical groups (the fields are given in the reference mark grid plates):



The following points are located for an azimuth of the defect □=90°, they "turn" if this one is different:

- EXT6: group of nodes made up of the node located in external skin on the right side at the base of the end tubes ($X=R_m+e/2, Y=\pi*R_m, Z=-\text{l\_tube\_p1}$),
- EXT5: group of nodes made up of the node located in external skin on the under-surface at the base of the end tubes ($X=R_m+e/2, Y=\pi*R_m/2, Z=-\text{l\_tube\_p1}$),
- EXT4: group of nodes made up of the node located in external skin on the left side at the base of the end tubes ($X=R_m+e/2, Y=0, Z=-\text{l\_tube\_p1}$),
- EXT3: group of nodes made up of the node located in external skin on the suction face at the base of the end tubes ($X=R_m+e/2, Y=-\pi*R_m/2, Z=-\text{l\_tube\_p1}$),
- EXT2: group of nodes made up of the node located in external skin at the base of the end tubes ($X=R_m+e/2, Y=-4*\pi*R_m/5, Z=-\text{l\_tube\_p1}$),
- EXT1 (= EXT6 on the elbow): group of nodes made up of the node located in external skin on the right side at the base of the end tubes ($X=R_m+e/2, Y=-\pi*R_m, Z=-\text{l\_tube\_p1}$),

- MIL6: group of nodes made up of the node located in external skin on the right side at the interface end tubes and bends ($X=R_m+e/2, Y=\pi*R_m, Z=0$),
- MIL5: group of nodes made up of the node located in external skin on the under-surface at the interface end tubes and bends ($X=R_m+e/2, Y=\pi*R_m/2, Z=0$),
- MIL4: group of nodes made up of the node located in external skin on the side at the interface end tubes and bends ($X=R_m+e/2, Y=0, Z=0$),
- MIL3: group of nodes made up of the node located in external skin on the suction face at the interface end tubes and bends ($X=R_m+e/2, Y=-\pi*R_m/2, Z=0$),
- MIL2: group of nodes made up of the node located in external skin at the interface end tubes and bends ($X=R_m+e/2, Y=-4*\pi*R_m/5, Z=0$),

- MIL1 (= MIL6 on the elbow): group of nodes made up of the node located in external skin on the right side at the interface end tubes and bends ($X=R_m+e/2$, $Y=-\pi*R_m$, $Z=0$),

- MED6: group of nodes made up of the node located in external skin on the right side more close to the median section of the part bends ($X=R_m+e/2, Y=\pi*R_m, Z=\alpha*R_c/2$),
- MED5: group of nodes made up of the node located in external skin on the under-surface more close to median section of the part bends ($X=R_m+e/2, Y=\pi*R_m/2, Z=\alpha*R_c/2$),
- MED4: group of nodes made up of the node located in external skin on the left side more close to median section of the part bends ($X=R_m+e/2, Y=0, Z=\alpha*R_c/2$),
- MED3: group of nodes made up of the node located in external skin on the suction face more close to the median section of the part bends ($X=R_m+e/2, Y=-\pi*R_m/2, Z=\alpha*R_c/2$),
- MED2: group of nodes made up of the node located in external skin more close to the median section of the part bends ($X=R_m+e/2, Y=-4*\pi*R_m/5, Z=\alpha*R_c/2$),
- MED1 (=MED6 on the elbow): group of nodes made up of the node located in external skin on the right side more close to the median section of the part bends ($X=R_m+e/2, Y=-\pi*R_m, Z=\alpha*R_c/2$),
- BORDTU: contour interns section at the end of the end tubes ($Z=-\text{l\_tube\_p1}$).

Groups of points useful for the boundary conditions of type beam:

- BOU1: group of nodes made up of the node located in external skin on the left side at the top of the P2 end or the bowl ($X=R_m-e/2, Y=0, Z=\alpha*R_c+\text{l\_tube\_p2}+\text{longueur bol}$),
- BOU3: group of nodes made up of the node located in external skin on the right side at the top of the P2 end or the bowl ($X=R_m-e/2, Y=+\pi*R_m, Z=\alpha*R_c+\text{l\_tube\_p2}+\text{longueur bol}$),
- P1 : node located at the center of section EXTUBE,
- P2: node located at the center of section CLGV.

Group of surface meshs:

- PEAUEXT: group of meshs containing the whole of the surface meshs constituting the external skin of the elbow and the ends ($X=R_m+e/2$),
- PEAUINT: group of meshs containing the whole of the surface meshs constituting the skin interns elbow and ends ($X=R_m-e/2$),
- FACE1: group of meshs containing the upper lip of the crack (Z1=0 plan$^-$) whose orientation of the normal is positive towards Z1 positive,
- FACE2: group of meshs containing the lower lip of the crack (Z1=0 plan$^+$) whose orientation of the normal is positive towards Z1 negative,
- EXTUBE: group of surface meshs constituting the end of the end tubes ($Z=-\text{l\_tube\_p1}$).

Très Important:

The elements of skin described above have an external outgoing normal in external skin and an outgoing normal interns in internal skin.

Group of voluminal meshs for the short cracks:

- BLOCFISS: group of meshs constituting the block fissures symmetrized,
- QUARBLOC: group of meshs constituting the quarter of initial block (Y1>0 and Z1<0),
- BLOCOCTO: group of meshs constituting the block fissures symmetrized and the octagone of incrustation,
- TORE1: half torus (Z1=0$^-$) containing the bottom of crack and part of FACE1,
- TORE2: half torus (Z1=0$^+$) containing the bottom of crack and part of FACE2 (complement of TORE1),
- ELBOW: group of meshs constituting the whole of the voluminal and surface meshs definite on the grid,
- BOWL: group of meshs constituting the grid of end of type bowl.

Group of voluminal meshs for the long cracks (a/c 0.2) :

- BLOCFISS: group of meshs constituting the block fissures symmetrized,
- BLOFISS1: group of meshs constituting the half-block fissures symmetrized ($Z \leq 0$),
- BLOFISS2: group of meshs constituting the half-block fissures symmetrized ($Z \geq 0$),
- TORE1: half torus (Z1=0$^-$) containing the bottom of crack and part of FACE1,
- TORE2: half torus (Z1=0$^+$) containing the bottom of crack and part of FACE2 (complement of TORE1),
- ELBOW: group of meshs constituting the whole of the voluminal meshs definite on the grid,
- BOWL: group of meshs constituting the grid of end of type bowl.

Group of nodes:

- FONDFISS: group of nodes constituting the bottom of crack describes in the order of Y1 negative in Y1 positive,
- CLGV: group of nodes constituting the end of the P2 end ($Z=\alpha * R_c + 1\_\text{tube\_p2}$),
- P_AXE_1: group of nodes constituting the small axis of the crack (Z1 = 0$^-$) ordered in the direction melts of crack - > emerging face,
- P_AXE_2: group of nodes constituting the small axis of the crack (Z1 = 0$^+$) ordered in the direction melts of crack - > emerging face,
- G_AXE_1: group of nodes constituting the main roads of the crack (Z1 = 0$^-$) ordered in the Y<0 direction in Y>0 for a circumferential crack and in the Z<0 direction in Z>0 for the other orientations of crack,
- G_AXE_2: group of nodes constituting the main roads of the crack (Z1 = 0$^+$) ordered in the Y<0 direction in Y>0 for a circumferential crack and in the Z<0 direction in Z>0 for the other orientations of crack,
- NOLIG1: group of nodes made up of the whole of the points of P_AXE_1 and the ligament located in the prolongation of this one in the thickness.
- NOLIG2: group of nodes made up of the whole of the points of P_AXE_2 and the ligament located in the prolongation of this one in the thickness.

5.4.1 Case of the half-structure

The following entities present but are associated with places different from the whole structure:

- **CLGV** : elements of membrane located in median section forming the transverse symmetry plane of the elbow. In the case of a circumferential crack, one will be able to deduce there the lip (entity FACE2) thanks to the operator `DEFI_GROUP` (`DIFFE`),
- **BOU1** : node located on the median section in external skin on the left side for an azimuth of the defect of 90° (this point also coincides with point MED4),
- **BOU3** : node diametrically opposed to BOU1 on the median section, located in external skin on the right side (this point also coincides with point MED6),
- **P2** : node located at the center section CLGV.

Entities FACE1, TORE1, BLOFISS1, P_AXE_1, G_AXE_1, NOLIG1, BOWL do not exist.

The boundary conditions for a half-structure in order to block displacements of rigid body and to simulate the conditions of symmetry are the following ones (α is the angle of the elbow and Φ the azimuth of the defect):

- Blocking of normal displacement to the median section (CLGV from which one will have withdrawn the lip of defect LEVRE2):
  DZ = 0 for a tube,
  DNOR =0 for an elbow.

- A point on the aforementioned section blocked in the plan of this one:
  DX = DY = 0 for a tube,
  DY = 0 and $\cos(\alpha) DX - \sin(\alpha) DZ = 0$ for an elbow.

- The symmetrically opposed point (located at the azimuth □1) with the precedent in the section, blocked in tangent displacement with the aforementioned section:
  $\sin(\Phi_1) DX + \cos(\Phi_1) DY = 0$ for a tube,
  $\sin(\Phi_1)\cos(\alpha) DX + \cos(\Phi_1) DY - \sin(\Phi_1)\sin(\alpha) DZ = 0$ for an elbow.

Note:

One can also for the half-structure plan to preserve the principle of the connection 3D-beam (used with whole modeling in MACR_ASCOUF_CALC) with a node in the middle of the median section (in fact P2).

5.4.2 Case of the quarter of structure

The modifications are similar to the preceding paragraph. Moreover, the two edges forming the longitudinal symmetry plane of the elbow are available:

- **BORD1** : elements of membrane located left side for an azimuth of defect $\Phi = 90°$,
- **BORD2** : elements of membrane located right side for an azimuth of defect $\Phi = 90°$.

The boundary conditions for a quarter of structure in order to block displacements of rigid body and to simulate the conditions of symmetry are the following ones (α is the angle of the elbow and Φ the azimuth of the defect):

- Blocking of normal displacement to the median section (CLGV from which one will have withdrawn the lip of defect LEVRE2):
  DZ = 0 for a tube,
  DNOR =0 for an elbow.

- Blocking of the longitudinal symmetry plane of the tubular structure:
  DNOR = 0 on BORD1 and BORD2.

- Blocking of displacement perpendicular to the longitudinal symmetry plane of one of points (BOU3 to avoid taking the point located in the zone of the defect which is BOU1) located at the intersection of the two plans previously quoted:
  $\cos(\Phi) DX + \sin(\Phi) DY = 0$ for a tube,
  $\cos(\Phi)\cos(\alpha) DX + \sin(\Phi) DY - \cos(\Phi)\sin(\alpha) DZ = 0$ for an elbow.

6 Examples

The following table gives some examples of use of `MACR_ASCOUF_MAIL`.

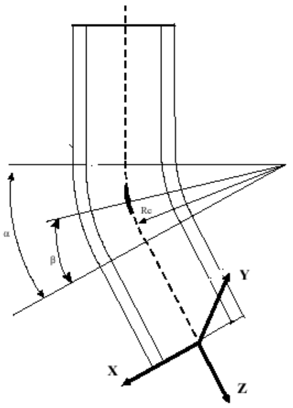
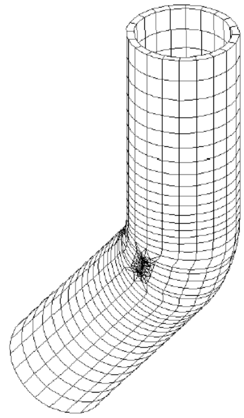
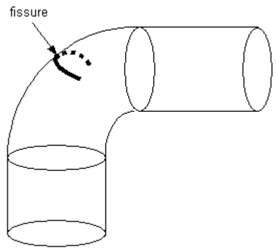
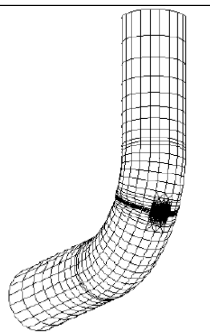
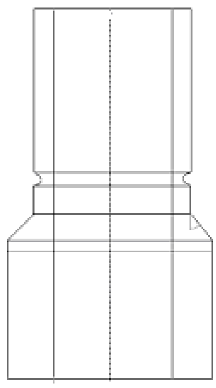
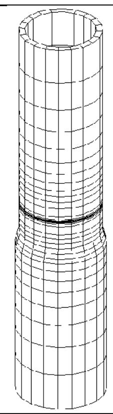
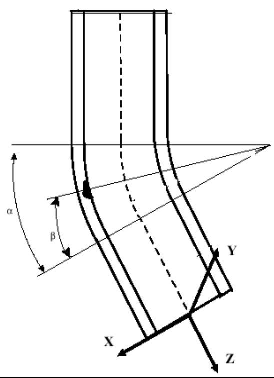
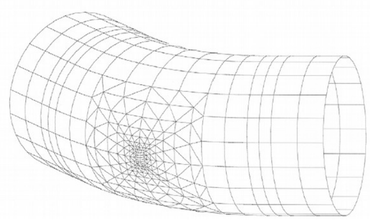
Type of defect	Structure	Grid
Elbow with longitudinal short crack (ascou15a)		
Elbow with circumferential long crack (ascou19a)		
Tube with transition from thickness and axisymmetric under-thickness (ascou06a)		
Elbow with under-thickness elliptic internal (ascou03a)		

Table: Examples of use of the macro order `MACR_ASCOUF_MAIL`

Besides the examples described here one will be able to consult the command files (file .comm) cases tests. The latter are in the /aster/v9/STA9/astest repertoire and bear the names ascou*.

6.1 Elbow with short crack

```
MA1 = MACR_ASCOUF_MAIL (

              EXEC_MAILLAGE=_F (  SOFTWARE = 'GIBI2000'),

              COUDE=_F (  ANGLE = 40. ,
                          R_CINTR = 654. ,
                          DEXT = 912.4,
                          THICK = 62.5,
                          L_TUBE_P1 = 1700. ,
                          L_TUBE_P2 = 1700.),

                FISS_COUDE=_F (  DEPTH = 10. ,
                                 LENGTH = 20. ,
                                 POSI_ANGUL = 20. ,
                                 AZIMUTH = 90. ,
                                 ORIEN = 0. ,
                                 CRACK = 'DEB_EXT',
                                 AXIS = 'NOT',
                                 NB_TRANCHE = 8,
                                 NB_SECTEUR = 3,
                                 NB_COURONNE = 2)
                     )
```

6.2 Elbow with elliptic under-thickness and extra thickness

```
MA2 = MACR_ASCOUF_MAIL (

              EXEC_MAILLAGE=_F (SOFTWARE = 'GIBI2000'),

              COUDE=_F (ANGLE = 40. ,
                       R_CINTR = 1354. ,
                          DEXT = 912.4,
                         THICK = 62.5,
                     L_TUBE_P1 = 1700. ,
                     L_TUBE_P2 = 1700. ,
                     SUR_EPAIS = 8.),

    SOUS_EPAIS_COUDE=_F (   TYPE = 'ELLI',
                      DEPTH = 20. ,
                       AXE_LONGI = 50. ,
                         AXE_CIRC = 100. ,
                      POSI_ANGUL = 20. ,
                          AZIMUTH = 0. ,
                      SOUS_EPAIS = 'INTERN',
                   NB_ELEM_LONGI = 4,
                    NB_ELEM_CIRC = 8)

                     )
```

6.3 Elbow with under-ép. elliptic and under-ép. axisymmetric

```
MA3 = MACR_ASCOUF_MAIL (

              EXEC_MAILLAGE=_F (  SOFTWARE = 'GIBI2000'),

              COUDE=_F (  ANGLE = 90. ,
                      R_CINTR = 1354. ,
                      DEXT = 912.4,
                      THICK = 62.5,
                      L_TUBE_P1 = 1700. ,
                      L_TUBE_P2 = 1700. ,),

              SOUS_EPAIS_MULTI= (

                    _F (  TYPE = 'ELLI',
                                  DEPTH = 20. ,
                                  AXE_LONGI = 50. ,
                                  AXE_CIRC = 100. ,
                                  POSI_ANGUL = 45. ,
                                  AZIMUTH = 90. ,
                                  SOUS_EPAIS = 'INTERN',
                                  NB_ELEM_LONGI = 4,
                                  NB_ELEM_CIRC = 8),
                    _F (  TYPE = 'AXIS',
                                  DEPTH = 10. ,
                                  AXE_LONGI = 10. ,
                                  POSI_ANGUL = 45. ,
                                  AZIMUTH = 180. ,
                                  SOUS_EPAIS = 'EXTERNAL',
                                  NB_ELEM_LONGI = 4,
                                  NB_ELEM_CIRC = 20,
                                  PRINT = 'YES'))
                 =_F IMPRESSION (FILE = 'MAIL.IDEAS'
                                  FORMAT  = 'IDEAS'
                                  UNIT    = 38)
                          )
```

6.4 Tube with short crack and transition from thickness

```
MA4 = MACR_ASCOUF_MAIL (EXEC_MAILLAGE=_F (SOFTWARE = 'GIBI2000'),

                        COUDE=_F (ANGLE         = 60. ,
                                  R_CINTR       = 654. ,
                                  L_TUBE_P1     = 1700. ,
                                  L_TUBE_P2     = 1700. ,
                                  TRANSFORM   = 'TUBE',
                                  TRAN_EPAIS    = 'YES',
                                  DEXT_T1       = 250. ,
                                  EPAIS_T1      = 15. ,
                                  EPAIS_TI      = 25. ,
                                  EPAIS_T2      = 40. ,
                                  ANGL_TETA1    = 5. ,
                                  ANGL_TETA2    = 15. ,
                                  ABSC_CURV_TRAN = 300.),
```

```
                    FISS_COUDE=_F (DEPTH  = 4. ,
                                   LENGTH    = 20. ,
                                   POSI_ANGUL  = 15. ,
                                   AZIMUTH      = 90. ,
                                   ORIEN       = 90. ,
                                   CRACK     = 'DEB_EXT',
                                   NB_TRANCHE  = 8,
                                   NB_SECTEUR  = 2,
                                   NB_COURONNE = 3,
                                   RAYON_TORE  = 0.5),
                   IMPRESSION=_F (UNIT  = 37
                                   FORMAT = 'CASTEM')
              )
```

6.5 Tube with axisymmetric crack and transition from thickness

```
MA5 = MACR_ASCOUF_MAIL (

                      EXEC_MAILLAGE=_F (LOGICIEL=' GIBI98',),

                      COUDE=_F (TRAN_EPAIS=' OUI',
                                EPAIS_T1=60.0,
                                EPAIS_T2=90.0,
                                L_TUBE_P2=900.0,
                                TRANSFORMEE=' TUBE',
                                L_TUBE_P1=1010.0,
                                DEXT_T1=660.0,
                                ABSC_CURV_TRAN=183.541,
                                ANGL_TETA1=30.0,
                                R_CINTR=340.0,
                                ANGLE=90.0,),
                 FISS_COUDE=_F (NB_COURONNE=3,
                                ABSC_CURV=150.0,
                                PROFONDEUR=7.5,
                                NB_TRANCHE=40,
                                LONGUEUR=0.,
                                AXIS=' OUI',
                                AZIMUT=0.0,
                                NB_SECTEUR=2,
                                FISSURE=' DEB_EXT',
                                RAYON_TORE=1.8,
                                ORIEN=90.0,),
                 IMPRESSION=_F (FORMAT=' IDEAS',),
                )
```

7 Bibliography

1) B. MARTELET - S. IGNACCOLO. Tool ASCOUF: Specification for the modeling of the connections of the elbows to the components of the primary loops. Note SEPTEN ENT MS/96007A of the 2/15/96.

2) I. EYMARD - MR. BONNAMY: Preprocessor ASCOUF - Manuel Utilisateur - Version 5. Note EDF/DER HI-74/95/025/C

3) S. ANDRIEUX - I. EYMARD: Definition of the geometrical transformation plate-tube-elbow. Note EDF/DER HI-74/95/004/B of the 4/11/95