Macro-command MACR_ASCOUF_CALC

1 Drank

To carry out the thermomechanical analysis of the elbow whose mesh was conceived with macro command MACR_ASCOUF_MAIL. **The lengths of the mesh produced by** MACR_ASCOUF_MAIL **are in millimetres**, it is necessary to take of it account in the units of the characteristics material and the loading.

The main steps of the macro command are:

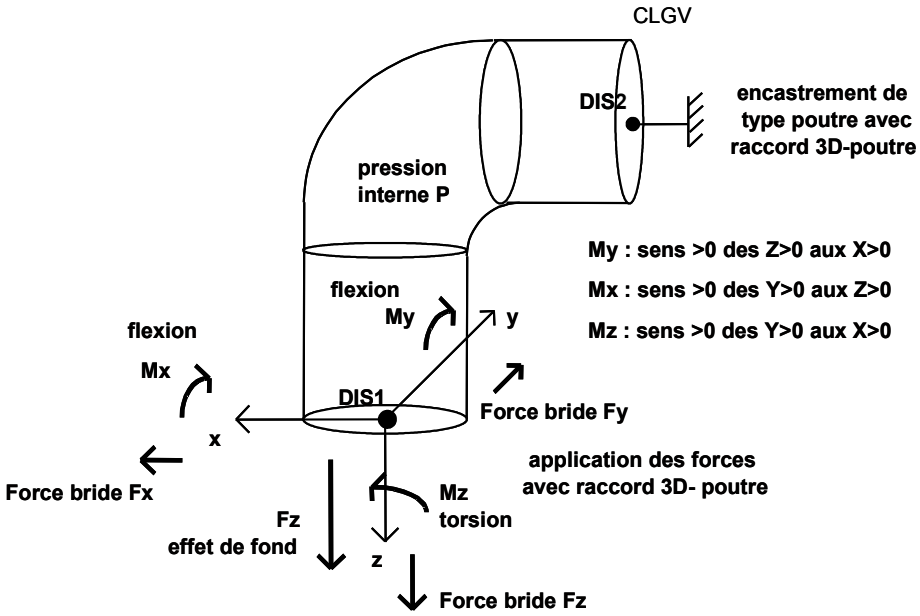
- assignment of the model by the command AFFE_MODELE,
- assignment of the materials by the command AFFE_MATERIAU,
- assignment of the characteristics of the discrete elements by the command AFFE_CARA_ELEM,
- definition of the boundary conditions of fixed support of type beam with connection 3D_POUTRE by the command AFFE_CHAR_MECA,
- definition of the mechanical loading (pressure, basic effect, load vector force) by the command AFFE_CHAR_MECA,
- definition of the thermal loading (temperature of fluid, coefficient of heat exchange) by the command AFFE_CHAR_THER_F,
- realization of linear thermal computation and or not linear linear mechanical computation by commands THER_LINEAIRE and STAT_NON_LINE,
- realization of the post processing by commands CALC_THETA, CALC_G, POST_RELEVE_T or POST_RCCM
- printing of postprocessing by commands IMPR_RESU, IMPR_TABLE.

2 Syntax

```
resu    [evol_noli]   = MACR_ASCOUF_CALC

(
   ♦TYPE_MAILLAGE=/                  "SAIN" ,                          [TXM]
                               /   "FISS_COUDE",
                               /   "FISS_AXIS_DEB",
                               /   "SOUS_EPAIS_COUDE",

   ◊   CL_BOL_P2_GV=_F      (
                            ♦ANGLE=           α ,                        [R]
                            ◊AZIMUT=/phi                ,                [R]
                                        /90 .   ,                 [DEFAULT]
                         ),

   ♦MAILLAGE=ma                ,                                        [mesh]

   ♦   MODELE=CO                 ("modmec")   ,                          [TXM]

   ◊   CHAM_MATER=CO     ("chmat")       ,                             [TXM]

   ◊   CARA_ELEM=CO          ("carael")      ,                          [TXM]

   ◊   FOND_FISS=CO          ("fonfiss") ,                             [TXM]

   ◊   RESU_THER=CO          ("resuth")      ,                          [TXM]

   ♦AFFE_MATERIAU=       _F (  ♦/                TOUT=' OUI',
                               /GROUP_MA=/       "COUDE"   ,          [TXM]
                                                 /"BOWL"   ,
                            ♦MATER=mat                     ,              [to
subdue]
                            ◊TEMP_REF=/             0.  ,              [DEFAULT]
                                                 /tref  ,              [R]
                         ),

   ◊PRES_REP=             _F (  ♦PRES=pres                  ,             [R]
                            ◊EFFE_FOND_P1=/         "OUI',            [DEFAULT]
                                                 /"NON",
                            ◊PRES_LEVRE=/        "OUI',
                                                 /"NON",              [DEFAULT]
                            ◊FONC_MULT=fmult                ,      /
   [function]
                                                                 /   [formula]
                         ),

   ◊ECHANGE=          _F (  ◊COEF_H=h                      ,      /
   [function]
                                                                 /   [formula]
                            ◊TEMP_EXT=chtex                 ,      /
   [function]
                                                                 /   [formula]
                         ),

   ◊TORS_P1=          _F (  ♦   |   FX=fx                  ,             [R]
                               |   FY=fy                  ,             [R]
                               |   FZ=fz                  ,             [R]
                               |   MX=mx                  ,             [R]
                               |   MY=my                  ,             [R]
                               |   MZ=mz                  ,             [R]
                            ◊FONC_MULT=fmult                ,      /
   [function]
```

```
                                                          /   [formula]
                          )
        |      COMP_ELAS= _F ( ♦RELATION=/                "ELAS",
                                                  /   "ELAS_VMIS_TRAC",
                          ),

    ◊SOLVEUR=            (see the document [U4.50.01])

    ◊NEWTON=                (see the document [U4.51.03])

    ◊CONVERGENCE=        (see the document [U4.51.03])

    ◊RECHERCHE_LINEAIRE=           (see the document [U4.51.03])

    ♦INCREMENT=             (see the document [U4.51.03])

    ◊   THETA_3D=     _F ( ♦   R_INF = R,                        [R]
                           ♦   R_SUP = R,                        [R]
                       ),

    ◊   IMPRESSION=   _F ( ◊FORMAT=/                  "RESULTAT",
[DEFAULT]
                                                  /   "ASTER"   ,
                                                  /   "CASTEM"  ,
                           ◊NIVE_GIBI=/              3,
                                                  /10,             [DEFAULT]
                                               ◊FORMAT=' IDEAS',
                           ◊VERSION=/                4,
                                                  / 5,             [DEFAULT]
                       ),

    ◊IMPR_TABLE=      _F ( ♦/TOUT_PARA=          "OUI',
                              /NOM_PARA      = | "TRESCA_MEMBRANE",
                                               | "TRESCA_MFLE",
                                               | "TRESCA",
                                               | "SI_LONG",
                                               | "SI_RADI",
                                               | "SI_CIRC",

                           # If TOUT_PARA = "OUI' or if NOM_PARA contains
                           # "SI_LONG" ou/et "SI_RADI" ou/et "SI_CIRC"
                           ♦ANGLE=                          α ,          [R]
                           ♦   /POSI_ANGUL          =beta ,       [R]
                              /POSI_CURV_LONGI      =sl   ,          [R]
                           ♦R_CINTR=Rc                    ,          [R]
                           # Finsi

                           ◊TRANSFORMEE=/             "TUBE",       [TXM]
                           /   "COUDE",                          [DEFAULT]
                           )

    ◊TITER=tx                 ,                                    [kN]

    ◊INFO=/1                      ,
[DEFAULT]
                       /2     ,                                   [I]

)
```

3 Operands



Appears 3-a: Applicable loading and boundary conditions on the elbow

3.1 Key word TYPE_MAILLAGE

Make it possible to recall which is the type of mesh produced by MACR_ASCOUF_MAIL :

♦TYPE_MAILLAGE =

/ "SAIN"	:	computation is carried out on a tube or bends healthy.
/ "FISS_COUDE"	:	computation is carried out on a tube or bends comprising a crack (fracture mechanics).
/ "SOUS_EPAIS_COUDE"	:	computation is carried out on a tube or bends with one or more under-thickness.
/ "FISS_AXIS_DEB"	:	computation is carried out on a tube or bends comprising an emerging axisymmetric crack.

To do calculations on a closed crack tip, it is thus necessary to indicate "FISS_AXIS_DEB" like type of mesh.

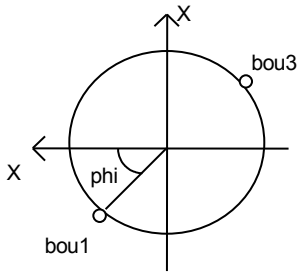
Note:

*If a crack is defined in the model (*FISS_COUDE *or* FISS_AXIS_DEB*), a checking of the interpenetration of the lips is carried out for all time step. If an interpenetration is detected, an alarm message is transmitted to announce it. It is pointed out that the contact is not taken into account in computation. The rate of refund of energy G is thus positive including where the crack tends to close again, which can lead to too penalizing results.*

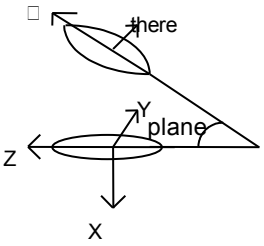
3.2 Key word CL_BOL_P2_GV

This key word should be used only when the elbow carried out with the macro-command of mesh MACR_ASCOUF_MAIL has a bowl connected to the nozzle P2 of conic section, cf [U4.CF.10 §4.3.6]. This results in the use of key word BOL_P2 with the value "GV" in the macro one of mesh. It proves indeed that the use of a connection 3D-beam employed as boundary condition for the nozzle P2 is then not licit in the case of a conic section like the bowl of type pipe of GV.

One then models a fixed support of type beam of the section at the end of the nozzle P2. The named section CLGV and node BOU1 defined on this section will use to block six rigid body motions. It is necessary nevertheless to take account of rotation carried out azimutalement to position (angle phi) crack as well as angle of the section with the reference user (angle α of the elbow):



section CLGV angle



locates elbow and section CLGV there

3.2.1 Operand ANGLE

♦ANGLE= α

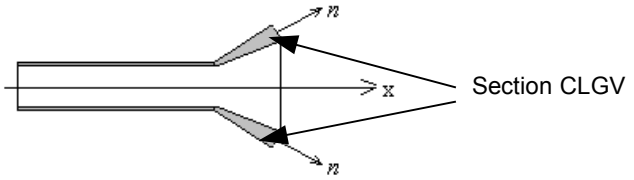
Angle between the references of the elbow and section CLGV, to see document [U4.CF.10 §5.3]. This angle corresponds to the angle of the elbow, cf [U4.CF.10 §4.3.1].

3.2.2 Operand AZIMUT

◊AZIMUT=/ phi,
/90. , [DEFAULT]

Angle phi indicating the azimuth of the center of crack and the position of the node $BOU1$. The fixed support is then represented by two conditions:

- The condition $\vec{u}.\vec{n}=0$ on the section $CLGV$ blocks already the three translations and two of rotations (the norm $\vec{n}$ with the section is not constant);



Cuts nozzle P2 and bowl of the type GV

- Blocking of tangent displacement DTAN to the section (rotation) for the node $BOU1$, this makes it possible to block rotation around the axis of symmetry of the bowl:
DTAN = $\sin(\theta)\cos(\varphi)\,DX+\cos(\varphi)\,DY-\sin(\theta)\sin(\varphi)\,DZ=0$.

3.3 Operand MAILLAGE

♦MAILLAGE=ma

One specifies here the mesh used. This mesh is resulting from macro-command MACR_ASCOUF_MAIL.

3.4 MODEL operand

♦MODELE=CO ("modmec")

Key word used to name the model mechanical for a later use apart from the macro-command.

3.5 Operand CHAM_MATER

Key word used to name by the command data structure of the type cham_mater produced AFFE_MATERIAU, for a later use apart from the macro-command.

3.6 Operand CARA_ELEM

Key word used to name by the command structure of the type cara_elem produced AFFE_CARA_ELEM, for a later use apart from the macro-command.

3.7 Operand FOND_FISS

Key word used to name the concept of the fond_fiss type produces DEFI_FOND_FISS by the command, for a later use apart from the macro-command.

3.8 Operand RESU_THER

Key word used to name result linear thermal computation (concept evol_ther), for a later use apart from the macro-command.

3.9 Key word AFFE_MATERIAU

Factor key word allowing to affect various materials on the mesh. The characteristics of the material are to be defined with command DEFI_MATERIAU upstream of the macro-command.

Note:

In the event of elbow with under-thickness, the postprocessing carried out at the conclusion of computation claims the definition of a working stress (factor keywords "RCCM"/"RCCM_FO" of DEFI_MATERIAU) for the material constituting the elbow .

3.9.1 Operand GROUP_MA

♦/TOUT = "OUI'

This key word makes it possible to affect on all meshes mesh.

/GROUP_MA

This key word makes it possible to affect the mesh groups according to:

COUDE mesh group corresponding to the part bends and the right nozzles,

BOWL mesh group corresponding to a nozzle of type bowl (cf macro-command MACR_ASCOUF_MAIL).

3.9.2 Operand MATER

♦MATER

Name of the material (cf orders DEFI_MATERIAU) that one wants to affect.

3.9.3 Operand TEMP_REF

◊TEMP_REF

Reference temperature for which there is no thermal strain (cf orders AFFE_MATERIAU).

3.10 Key word PRES_REP

3.10.1 Operand NEAR

♦PRES= close

One indicates here the value of the pressure which applies to the internal skin of the elbow and the nozzles.

This pressure is also used to calculate the tractive effort representing the basic effect which the taking into account is automatically assured (cf orders AFFE_CHAR_MECA key word EFFE_FOND).

The value of this force is: $Tfond = pres \times \frac{R_i^2}{R_e^2 - R_i^2}$

3.10.2 Operand EFFE_FOND_P1

◊EFFE_FOND_P1

Makes it possible to activate or not the application of the evoked basic effect [§3.11.1] of this document. By default EFFE_FOND_P1 is worth "OUI'.

3.10.3 Operand PRES_LEVRE

◊PRES_LEVRE

Makes it possible to activate or not the application of the pressure, evoked with [§3.11.1] of this document, on the lips of crack when this one emerges in intern skin. By default PRES_LEVRE is worth "NON".

Attention to be used PRES_LEVRE = "OUI' only for the cracks which emerge in intern skin.

3.10.4 Operand FONC_MULT

◊FONC_MULT = fmult

multiplying Function of the loading (pressure plus basic effect). By default: $f = 1$. This one is to be defined upstream macro-command thanks to command DEFI_FONCTION or FORMULA.

3.11 Key word ECHANGE

Factor key word making it possible to apply conditions of exchange to the skin interns elbow (cf orders AFFE_CHAR_THER_F) and to carry out a linear thermal computation (THER_LINEAIRE) preliminary to mechanical computation. For the thermal, one uses the solver and the parameter theta by default. The initial temperature is determined by a steady computation. The initial temperature is worth the temperature of the fluid at initial time (cf operand TEMP_EXT).

3.11.1 Operand COEF_H

◊COEF_H= H

Value of the coefficient of heat exchange on the skin interns elbow given in the form of function of time.

This one is to be defined upstream macro-command thanks to commands DEFI_FONCTION or FORMULA.

3.11.2 Operand TEMP_EXT

◊TEMP_EXT= chtex

Value of the temperature of the fluid inside the elbow given in the form of function of time.

This one is to be defined upstream macro-command thanks to commands DEFI_FONCTION or FORMULA.

3.12 Key word TORS_P1

◊ TORS_P1=

key word TORS_P1 makes it possible to apply a load vector force. This torsor applies to the node of beam $P1$ (indicated $DIS1$ on the Figure 3-a).
In order to block motions of rigid bodies, one blocks the six degrees of freedom of the node of beam $P2$ located at the center of the section $CLGV$.

3.12.1 Operands FX, FY, FZ, MX, MY, MZ

the components FX, FY, FZ, MX, MY, MZ of the torsor of the forces must be provided in the reference of the mesh. At least one of the components must be indicated.

3.12.2 Operand FONC_MULT

◊FONC_MULT = fmult

multiplying Function of loading TORS_P1. By default: $f=1$. This one is to be defined upstream macro-command thanks to commands DEFI_FONCTION or FORMULA.

3.13 Key word COMP_ELAS

♦RELATION =

Standard of elastic behavior model used to carry out mechanical computation with STAT_NON_LINE:

"ELAS"	linear elastic behavior,
"ELAS_VMIS_TRAC"	nonlinear elastic behavior of Von Mises with nonlinear isotropic hardening.

3.14 Key word solver

One defines the solver retained for mechanical computation. The syntax of this key word common to several commands is described in the document [U4.50.01]. It is used only for mechanical computation.

3.15 Key word NEWTON

Specifies the characteristics of the method of resolution of the nonlinear incremental mechanical problem. The syntax of this key word is described in the document [U4.51.03]. It is used only for mechanical computation.

3.16 Key word CONVERGENCE

Specifies the convergence criteria of mechanical computation. The syntax of this key word is described in the document [U4.51.03]. It is used only for mechanical computation.

3.17 Key word RECH_LINEAIRE

Specifies the linear mode of search of the solver. The syntax of this key word is described in the document [U4.51.03]. It is used only for mechanical computation.

3.18 Key word INCREMENT

during Defines the intervals of time taken in the incremental method a linear or mechanical thermal computation nonlinear. Time step used for computations thermal and mechanics are identical. The syntax of this key word is described in the document [U4.51.03].

3.19 Key word THETA_3D

This key word, usable for postprocessing in fracture mechanics, is used to define contour for the field theta in order to calculate total G and local $G(s)$ rate of energy restitution (cf orders CALC_G [U4.82.03]). The fields $thêta$ and $G(s)$ are smoothed by polynomials of Legendre of degree 4, except for axisymmetric cracks (lissage with the Lagrange shape functions). This key word is répétable as many times as one wants. The choice of several couples of radius makes it possible to check the stability of the method.

The contact is not taken into account in computation, but an alarm message is transmitted if the two lips of crack interpenetrate. In this case, the rate of refund of energy G will remain positive including where the crack tends to close again, which can lead to too penalizing results.

3.19.1 Operand R_INF

♦ R_INF=r [R8]

Makes it possible to indicate the lower value of the radius at a peak of crack for calculating rate of energy restitution G.

3.19.2 Operand R_SUP

♦R_SUP=R [R8]

Makes it possible to indicate the higher value of the radius at a peak of crack for calculating rate of energy restitution G.

3.20 Key word PRINTING

3.20.1 Operand FORMAT

◊FORMAT

Makes it possible to specify the format of printing of result and/or the mesh. By default the format is "RESULTAT". If one wishes to print the mesh, it is necessary to use format "ASTER" and to put a file of the mast type as a result in the profile of study.

3.20.2 Operand VERSION

◊VERSION

If and only if operand FORMAT is worth "IDEAS". This operand makes it possible to specify the version of the Ideas software. By default VERSION is worth 5.

3.20.3 Operand NIVE_GIBI

◊NIVE_GIBI

If and only if operand FORMAT is worth "CASTEM". This operand makes it possible to specify the level of the software GIBI in which the mesh will be printed. By default NIVE_GIBI is worth 10.

3.21 Key word IMPR_TABLE

This key word makes it possible of results to activate the printing of the arrays for postprocessing on the ligaments concerning the elbows with under-thickness.

3.21.1 Operand TOUT_PARA

TOUT_PARA = "OUI'

Printing of all the values of the parameters of the array. The printing contains the elements enumerated below, in the order where they are described.

For the ligaments representing the under-thickness and those contained in the section including the center of the under-thickness (ligaments $CIRxx$ $LONxx$ $PCENxx$ $INTRx$ $EXTRx$ $FGAUx$ $FDROx$ $EGAx$ $EXDRx$ $INDRx$, $INGAx$):

- Ligament where the membrane stress (named PM) is maximum.
- Ligament where the stress of membrane-bending at the origin of the segment (named PMB) is maximum.
- Ligament where the stress of membrane-bending at the end of the segment (named PMB) is maximum.
- Ligament where the average radial stress (named $SIXX$) is maximum.
- Ligament where the average longitudinal stress (named $SIYY$) is maximum.
- Ligament where the average circumferential stress (named $SIZZ$) is maximum.
- Node and ligament where the stress of Tresca (named $TRESCA$) is maximum.

For the same ligaments as previously but also those contained in the median sections of the elbow and interface with nozzles (ligaments $xxxxMI$ $xxxxTU$, $xxxxGV$):

- List values of the membrane stress (named PM) for each ligament.
- List values of the stress of membrane-bending at the origin of the segment (named PMB) for each ligament.
- List values of the stress of membrane-bending at the end of the segment (named PMB) for each ligament.
- List values of average radial stress (named $SIXX$) for each ligament.
- List values of average longitudinal stress (named $SIYY$) for each ligament.
- List values of average circumferential stress (named $SIZZ$) for each ligament.
- List stresses of Tresca (named $TRESCA$) on each node of each ligament.

3.21.2 Operand NOM_PARA

NOM_PARA = para

Makes it possible to choose a parameter list among all the possible ones:
"TRESCA", "TRESCA_MEMBRANE", "TRESCA_MFLE", "SI_LONG", "SI_RADI", "SI_CIRC".

Note:

This remark is valid for [§3.23.1] and [§3.23.2].
The stresses are given in the local coordinate system of the section containing the ligament:
- *radial stress " SI_RADI " corresponds in the results file to SIXX,*
- *longitudinal stress " SI_LONG " corresponds in the results file to SIYY,*
- *circumferential stress " SI_CIRC " corresponds in the results file to SIZZ.*

The computation of these stresses in local coordinate system requires the carryforward of the parameters α , Rc, β or sl and TRANSFORMEE defined in the macro-command of mesh .

3.21.3 Operand ANGLE

♦ ANGLE= α

Value of the angle of the elbow in degrees. Here it is necessary to give the same value as in macro-command MACR_ASCOUF_MAIL (cf [U4.CF.10, §4.3.1]).

3.21.4 Operand R_CINTR

♦R_CINTR=Rc

Value of the bend radius of the elbow. Here it is necessary to give the same value as in macro-command MACR_ASCOUF_MAIL (cf [U4.CF.10, §4.3.2]).

3.21.5 Operand POSI_CURV_LONGI

♦/POSI_CURV_LONGI=sl

Value of the longitudinal position of the center of the under-thickness given by the curvilinear abscisse along the axis of the elbow on the external skin of this one, counted positively from the interface with the nozzle P1 length l_tube_p1. Here it is necessary to give the same value as in macro-command MACR_ASCOUF_MAIL (cf [U4.CF.10, §4.4.5]).

3.21.6 Operand POSI_ANGUL

/POSI_ANGUL =beta

Value of the longitudinal position of the center of the under-thickness given by the angle in degrees formed by the section containing this one and the section to the interface with the nozzle length l_tube_p1. Here it is necessary to give the same value as in macro-command MACR_ASCOUF_MAIL (cf [U4.CF.10, §4.4.6]).

3.21.7 Operand TRANSFORMEE

◊TRANSFORMEE=/ "TUBE",
/ "COUDE", [DEFAULT]

Makes it possible to define the type of transformation applied in the macro-command of mesh. Here it is necessary to give the same value as in macro-command MACR_ASCOUF_MAIL (cf [U4.CF.10, §4.4.6]).

3.22 Operand TITER

Titrates data structure result. See [U4.50.01].

3.23 Operand INFO

◊INFO =

Indicates the level of printing of the results of the operator,

1: no printing,
2: relative information printing with the mesh.

The printings are made in the file "MESSAGE".

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