Operator CALC_THETA

1 Drank

To define a theta field for the computation of rate of energy restitution and the stress intensity factors.

In the frame of the fracture mechanics, this operator allows to define nodes of mesh: on all the

- the modulus of the field theta,
- in 2D the direction of propagation of the crack tip (equalizes with that of the field theta) with key word DIRECTION,
- in 3D the direction of the field theta calculated automatically starting from the directions of propagation of the nodes in crack tip. These directions are recovered by the concept of the fond_fiss type (produced by the operator DEFI_FOND_FISS), or by keys key DIRE_THETA or DIRECTION,
- radius $Rinf$ and $Rsup$ of contours surrounding the crack tip and used to define the field theta geometrically.

In 2D the crack tip is tiny room to a node and the contours are circular. In 3D radius can be variable with the curvilinear abscisse of the crack tip and $Rinf$, $Rsup$ define two deformed and variable cylinders then surrounding the crack tip.

The field theta is used in command CALC_G [U4.82.03] for the computation of the parameters characteristic of the fracture mechanics. The field theta can be directly defined besides in this operator.

The product concept is of cham_no_sdaster type.

2 Syntax

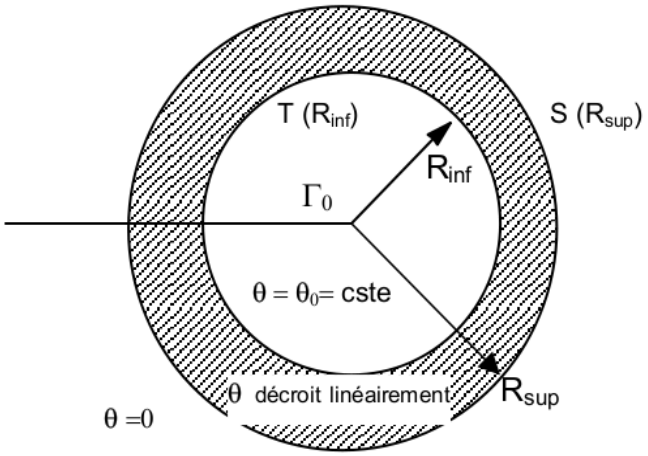
```
   theta [cham_no_sdaster] = CALC_THETA

   (  ◊OPTION    =      "CONTOUR",                              [DEFAULT]
                    /   "TAPE",
      ♦  MODELS = Mo,                                          [model]
      ♦  /♦     FOND_FISS = FF,                                [fond_fiss]
            ♦THETA_3D=        _F (  ♦/TOUT         = "OUI',
                                    /GROUP_NO  = lgno   ,     [l_gr_noeud]
                                    /NOEUD     = lno ,    [l_noeud])
                                 ♦  /  ♦  MODULE    = theta ,  [R]
                                       ◊  R_INF     = R,    [R]
                                       ◊R_SUP      = R  ,    [R]
                                    /♦MODULE_FO       = thetaz,
[function]
                                       ♦R_INF_FO   = rz,     [function]
                                       ♦R_SUP_FO   = Rz,     [function]
                                 ),
         /    ♦  THETA_2D  = _F (    ♦  /GROUP_NO  = gno,        [l_gr_noeud]
                                    /NOEUD     = No  ,        [l_noeud])
                                 ♦   MODULE = modulus,        [R]
                                 ♦   R_INF  = rinf,           [R]
                                 ♦   R_SUP  = rsup,           [R]
                              ),
      ◊/DIRECTION       = (  d1, d2, d3),              [l_R]
         /DIRE_THETA       =chamno      ,
[cham_no_sdaster]
      ◊IMPRESSION=_F       ( ◊FORMAT=/           "EXCEL",        [DEFAULT]
                                       /   "AGRAF",
                           ◊  UNITE=/8         ,               [DEFAULT]
                                       /unit  ,           [I]
                        )
   )
```

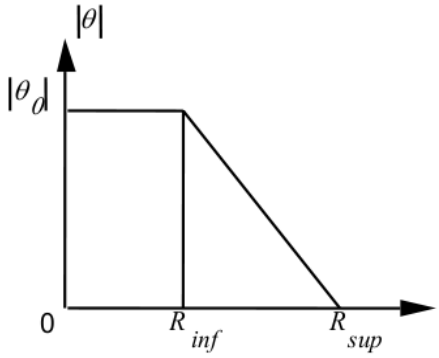
3 Operands

This way introduce the field θ is geometrical [R7.02.01]. It amounts giving itself two radius R_{inf} $R_{\sup}$, and $|\theta|$ in each node of the crack tip by the key word factor THETA_3D or THETA_2D. One carries out computations of distance from a knot slip to the crack tip to determine the value deen θ this node.

More precisely, in any node of the crack tip Γ_0, located by his curvilinear abscisse *S*, one can define a normal plane P into which the field θ is introduced in such way that after being itself given 2 volumes T and S (deformed cylinders) surrounding the crack tip, one a:

- $|\theta|=\theta_0=cste$ in $T(R_{\inf})$
- $|\theta|$ varies linearly compared to the radius in contour $S(R_{\sup})/T(R_{\inf})$
- $|\theta|=0$ outside $S(R_{\sup})$





3.1 Operand MODELS

♦ MODELS = Mo,
Name of the model concept which defines the elements on which the field is calculated θ.

3.2 Fracture mechanics - problem 3D

3.2.1 Operand FOND_FISS

/♦ FOND_FISS = FF,

Name of the concept FF of the fond_fiss type, produces DEFI_FOND_FISS, container by the command:

- the ordered list of the nodes describing the crack tip,

- the list of meshes describing the upper lip of crack,
- the list of meshes of the lower lip of crack if this one exists (case of an asymmetric problem).

3.2.2 Operand THETA_3D

/ ♦ THETA_3D =

Defines the nodes or the nodes groups entirely describing the crack tip where one affects radius contour and the modulus of θ.
All the nodes of the crack tip are specified by the operands:

/TOUT = taken into account of the totality of the nodes of the crack tip.

/GROUP_NO = taken into account of a under-part of the crack tip made up of the list of nodes groups specified.

/NOEUD = taken into account of a under-part of the crack tip made up of the list of the nodes specified.

Both radius defining the contour and the modulus of θ can be introduced either by constant actual values which are arguments of single-ended spanner keys R_INF, R_SUP and MODULE ; maybe by functions of the curvilinear abscisse on the directed crack tip, which are arguments of single-ended spanner keys R_INF_FO, R_SUP_FO and MODULE_FO.
When radius are not function of the curvilinear abscisse, operands R_INF and R_SUP are optional. If they are not indicated, they are automatically calculated starting from the maximum H of the sizes of meshes connected to the nodes of the crack tip. These sizes of meshes in each nodes of the bottom are calculated in command DEFI_FOND_FISS and are present in the concept fond_fiss [D4.10.01]. It was selected to pose R_SUP = 4:00 and R_INF = 2:00. If one chooses the value automatically calculated for R_SUP and R_INF, it is advisable however to make sure that these values (displayed in the file .mess) are coherent with dimensions of structure.

3.2.3 Operands DIRE_THETA and DIRECTION

/DIRECTION = (d1, d2, d3),

List of the values of the three components of the direction of the field θ on the crack tip when this one is not calculated.

/DIRE_THETA =chamno ,

Makes it possible 3D to introduce in the direction of the field θ on all the nodes of the crack tip by the means of a CREA_CHAMP precondition.

These options are optional: by defaults these directions are calculated automatically starting from the concept FF resulting of the command DEFI_FOND_FISS [U4.82.01] (normal with the crack tip in the plane of the lips). If the direction is given, it must be orthogonal with the norm with the lips of the crack, which is defined in operator DEFI_FOND_FISS (key word NORMAL).

3.3 Fracture mechanics - problem 2D

3.3.1 Operand THETA_2D

/ ♦ THETA_2D =

Key word factor defining the node of the crack tip:
/GROUP_NO = gno (nodes group limited to a node)

/NOEUD = No

the modulus from θ and the two radius are arguments of single-ended spanner keys MODULE, R_INF, R_SUP.

3.3.2 Operand DIRECTION

```
/DIRECTION     = (  d1, d2, d3),
```

List of the values of the three components of the direction of the field θ on the crack tip when this one is not calculated. In 2D this key word is compulsory: it is necessary to provide a vector of the form (d1, d2, 0).

The direction must be orthogonal with the norm with the lips of the crack, which can be defined in operator DEFI_FOND_FISS (key word NORMAL).

3.4 Operand PRINTING

```
◊   FORMAT=/         "EXCEL"    ,          [DEFAULT]
              /   "AGRAF"    ,
◊   UNITE=/8              ,                [DEFAULT]
              /unit  ,
```

Key word factor making it possible to print on the logical file of unit links (para default 8) for each node of the crack tip rinf, rsup, the modulus and the direction of the field theta. Format "AGRAF" makes it possible post-to treat the printing by Agraf.

4 Assignment

4.1 examples of a field θ in 2D by actual values

One affects on the node of the crack tip $|\theta|=1$ R_INF = 1 and R_SUP = 2

```
    THET2 = CALC_THETA   ( MODELS     = Mo,
                           THETA_2D =_F (   NOEUD  = ("NO29"),
                                            MODULE = 1. , R_INF = 1. , R_SUP =
2.),
                           DIRECTION  = (1. , 1. , 0.),
                         )
```

with Mo the model concept produce AFFE_MODELE by the command.

4.2 Assignment of a field θ in 3D by actual values

On the crack tip one affects nodes on all the $|\theta|=1$, $R_{INF}=2.$ and $R_{\mathrm{SUP}}=5.$ by constant actual values.

The direction of the field θ east given on each one of these nodes, it is worth $(1.0.0.)$.

```
    THET3 = CALC_THETA   ( OPTION     = ' COURONNE', MODELS =MO,
                           FOND_FISS =FF1,
                           THETA_3D   =_F (TOUT = "OUI',
                                            MODULE = 1. , R_INF = 2. , R_SUP =
5.),
                           DIRECTION  = (   1. , 0. , 0.),
                         )
```

with Mo the model concept produce AFFE_MODELE by the command.
ff1 the concept of the fond_fiss type produces DEFI_FOND_FISS by the command.

4.3 Assignment of a field θ in 3D by actual values and function with rule of overload

•On the crack tip one affects on the nodes group $GRN1$ $|\theta|=1$. $R_{\mathrm{inf}}=2.$ and $R_{\mathrm{sup}}=5.$ by constant actual values, and on the nodes group $GRN2$ $|\theta|$, R_{inf} and R_{sup} by functions.

The direction of the field θ is calculated automatically with the nodes of the crack tip.

```
    THETA1 = CALC_THETA ( OPTION   = "CONTOUR", MODELS = Mo,
                          FOND_FISS =ff1,
                          THETA_3D = (_F (GROUP_NO = "GRN1",
                                          MODULE = 1. ,
                                          R_INF = 2. , R_SUP = 5.),
                                         _F (GROUP_NO = "GRN2",
                                          MODULE_FO=fo,
                                          R_INF_FO=f1, R_SUP_FO=f2),
                        )
```

with:

Mo the model concept produces AFFE_MODELE by the command.
ff1 the concept of the fond_fiss type produces DEFI_FOND_FISS by the command.

GRN1 = {NO3 NO7 NO10}, GRN2 = {NO13 NO15}

the crack tip is made up by the nodes: $NO3$ $NO7$ $NO10$ $NO13$, $NO15$ in an ordered way.

f0, f1, f2 are respectively the functions defining $|\theta|$ and the two radius contours for $GRN2$ products by the command DEFI_FONCTION.

Note:

GRN1 and GRN2 must completely describe the crack tip represented in the concept `ff1` *.*

•On the crack tip one affects $|\theta|$, $R_{\inf}$ and $R_{\sup}$ by function except with the nodes $NO29$ and $NO15$ where one affects $|\theta|=1.$ $R_{\mathrm{INF}}=2.$ $R_{\mathrm{SUP}}=3.$ by constant actual values.

Direction of the champest θ calculated with the nodes of the crack tip.

```
    THETA2 = CALC_THETA (  OPTION   = ' COURONNE', MODELS = Mo, FOND_FISS
=ff3,
                           THETA_3D =_F (TOUT = ' OUI'
                                        MODULE_FO=fa,
                                        R_INF_FO=fb, R_SUP_FO=fc),
                                     _F (NOEUD = ("NO29", "NO15"),
                                        MODULE = 1. ,
                                        R_INF = 2. , R_SUP = 3.  ),),
                         )
```

with:

`Mo` the model `concept` produces AFFE_MODELE `by the command`.

`ff3` the concept of the fond_fiss `type` produces DEFI_FOND_FISS `by the command`.

`F, Bfrs, FC` are respectively the functions defining $|\theta|$ and the two radius contours for all the crack tip, products by the command `DEFI_FONCTION`.

Note:

The rule of overload applies here for the nodes of the crack tip $NO29$ *and* $NO15$ *.*