Operators AFFE_CHAR_THER and AFFE_CHAR_THER_F

1 Goal

To affect loadings and boundary conditions thermal on a model.

For the operator AFFE_CHAR_THER, the affected values do not depend on any parameter and are defined by actual values.

For the operator AFFE_CHAR_THER_F, the values are functionS of one or several parameters to be chosen as a whole (INST, X, Y, Z). For the loadings used in non-linear thermics, the functions depend only on the temperature (TEMP) and must be tabulées. Moreover, for certain loadings (for example SOURCE), the values can depend on the variables of order.

These functions must be defined beforehand by the call to one of the operators:

- DEFI_CONSTANTE [U4.31.01];
- DEFI_FONCTION [U4.31.02];
- DEFI_NAPPE [U4.31.03];
- FORMULA [U4.31.0 5];
- CALC_FONC_INTERP [U4.32.01].

The produced concept is of type char_ther.

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2 General syntax

```
CH [char_ther]  =  AFFE_CHAR_THER

          (  ♦  MODEL =   Mo,                                          [model]
             ◊  DOUBLE_LAGRANGE  =  /'YES',                            [defect]
                                    /'NOT'

             ♦  |  TEMP_IMPO =      (see keyword TEMP_IMPO        )
                |  FLUX_REP =       (see keyword FLUX_REP         )
                |  RADIATION =      (see keyword RADIATION     )
                |  EXCHANGE =          (see keyword EXCHANGES        )
                |  SOURCE =         (see keyword SOURCE        )
                |  PRE_GRAD_TEMP =  (see keyword PRE_GRAD_TEMP )
                |  LIAISON_DDL =    (see keyword LIAISON_DDL      )
                |  LIAISON_GROUP =  (see keyword LIAISON_GROUP )
                |  LIAISON_MAIL =   (see keyword LIAISON_MAIL     )
                |  ECHANGE_PAROI =  (see keyword ECHANGE_PAROI )
                |  LIAISON_UNIF =   (see keyword LIAISON_UNIF     )
                |  LIAISON_CHAMNO=  (see keyword LIAISON_CHAMNO   )
                |  CONVECTION=      (see keyword CONVECTION    )
                |  EVOL_CHAR=       (see keyword EVOL_CHAR        )
           )


CH [char_ther]  =  AFFE_CHAR_THER_F

           (  ♦  MODEL =   Mo,                                          [model]
              ◊  DOUBLE_LAGRANGE  =  /'YES',                            [defect]
                                     /'NOT'

              ♦  |  TEMP_IMPO =      (see keyword TEMP_IMPO        )
                 |  FLUX_REP =       (see keyword FLUX_REP         )
                 |  FLUX_NL =        (see keyword FLUX_NL          )
                 |  RADIATION =      (see keyword RADIATION     )
                 |  EXCHANGE =          (see keyword EXCHANGES        )
                 |  SOURCE =         (see keyword SOURCE        )
                 |  PRE_GRAD_TEMP=   (see keyword PRE_GRAD_TEMP )
                 |  LIAISON_DDL =    (see keyword LIAISON_DDL      )
                 |  LIAISON_GROUP =  (see keyword LIAISON_GROUP )
                 |  ECHANGE_PAROI =  (see keyword ECHANGE_PAROI )
                 |  LIAISON_UNIF =   (see keyword LIAISON_UNIF     )
                 |  CONVECTION =     (see keyword CONVECTION    )
                 |  SOUR_NL =        (see keyword SOUR_NL          )
           )
```

3 General information

Possible error messages related to the order AFFE_CHAR_THER

It happens sometimes that a thermal ordering of calculation (THER_LINEAIRE, THER_NON_LINE,...) stop in fatal error during the calculation of the second elementary members due to the loadings defined in the orders AFFE_CHAR_THER_*.

When the code stops during these elementary calculations, important information of the error message is the name of the option of calculation required by the code. The name of this option is in general unknown to the user and it is thus difficult for him to understand the message.

In the table below, one gives in with respect to the names of the options of calculation, the name of the order and the keyword factor which make it possible to activate this option.

Elementary option of calculation	Order	Keyword factor
CHAR_THER_FLUNL	AFFE_CHAR_THER_F	FLUX_NL
CHAR_THER_FLUN_F	AFFE_CHAR_THER_F	FLUX_REP
CHAR_THER_FLUN_R	AFFE_CHAR_THER	FLUX_REP
CHAR_THER_FLUTNL	AFFE_CHAR_THER	CONVECTION
CHAR_THER_FLUTNL	AFFE_CHAR_THER_F	CONVECTION
CHAR_THER_FLUX_F	AFFE_CHAR_THER_F	FLUX_REP
CHAR_THER_FLUX_R	AFFE_CHAR_THER	FLUX_REP
CHAR_THER_GRAI_F	AFFE_CHAR_THER_F	PRE_GRAD_TEMP
CHAR_THER_GRAI_R	AFFE_CHAR_THER	PRE_GRAD_TEMP
CHAR_THER_PARO_F	AFFE_CHAR_THER_F	ECHANGE_PAROI
CHAR_THER_PARO_R	AFFE_CHAR_THER	ECHANGE_PAROI
CHAR_THER_SOUR_F	AFFE_CHAR_THER_F	SOURCE
CHAR_THER_SOUR_R	AFFE_CHAR_THER	SOURCE
CHAR_THER_TEXT_F	AFFE_CHAR_THER_F	EXCHANGE
CHAR_THER_TEXT_R	AFFE_CHAR_THER	EXCHANGE
CHAR_THER_SOURNL	AFFE_CHAR_THER_F	SOUR_NL

4 Operands

4.1 General information on the operands

4.1.1 Two forms of operands under a keyword factor

The operands under a keyword factor are of two forms:

- operands specifying the topological entities where the loadings (keywords are affected GROUP_NO and GROUP_MA, etc…). The arguments of these operands are identical for the two operators.
- operands specifying the affected values (TEMP, COEF_H, etc…). The significance of these operands is the same one for the two operators but the arguments of these operands are all of the real type for the operator AFFE_CHAR_THER and of the type function (created by one of the operators DEFI_FONCTION, DEFI_NAPPE, DEFI_CONSTANTE, FORMULA or CALC_FONC_INTERP) for the operator AFFE_CHAR_THER _F.

We will thus not distinguish in this document, except fast mention of the opposite, the two operators AFFE_CHAR_THER and AFFE_CHAR_THER_F.

4.1.2 Topological entities of assignment of the loadings

In a general way, the topological entities on which values must be affected are defined:

- by nodes while using the operand GROUP_NO allowing to introduce a list of group of nodes,
- by mesh by using the operand GROUP_MA allowing to introduce a list of groups of meshs,

Rule:

To define the field of assignment most simply possible, one uses the rule of overload, it is the last assignment which precedes.

4.2 Operand MODEL

♦ MODEL = Mo,

Concept produced by the operator AFFE_MODELE [U4.41.01] where are defined the types of finite elements affected on the grid.

4.3 Operand DOUBLE_LAGRANGE

◊ DOUBLE_LAGRANGE = 'YES'/'NOT'

This keyword makes it possible to say if the user or not wishes to duplicate the multipliers of Lagrange used to define dualiser the boundary conditions in the assembled matrix.
Concretely, to duplicate the multipliers of Lagrange makes it possible to use linear solveurs not allowing the swivelling. Not to duplicate Lagrange makes it possible to reduce the number of degree of freedom of the problem (and thus size of the problem to be solved) but its use is limited to solveurs MUMPS and Petsc.

4.4 Keyword TEMP_IMPO

4.4.1 Goal

Keyword factor usable to impose, on nodes or groups of nodes, a temperature.

According to the name of the operator called, the values are provided directly (AFFE_CHAR_THER) or via a concept of the type function (AFFE_CHAR_THER_F).

4.4.2 Syntax

- for AFFE_CHAR_THER

```
TEMP_IMPO = _F (♦ |  ALL      =     'YES',
                  |  GROUP_NO =       lgno,              [l_gr_noeud]
                  |  GROUP_MA =       lgma,              [l_gr_maille]

                ♦ /  TEMP         =   T,                 [R]
                  /  |  TEMP_MIL =    tinf,              [R]
                     |  TEMP_INF =    tinf,              [R]
                     |  TEMP_SUP =    tsup,              [R]
               )
```

- for AFFE_CHAR_THER_F

```
TEMP_IMPO = _F (♦ |  ALL      =     'YES',
                  |  GROUP_NO =       lgno,              [l_gr_noeud]
                  |  GROUP_MA =       lgma,              [l_gr_maille]

                ♦ /  TEMP          =  tf,                [function]
                  /  |  TEMP_MIL   =  tf,                [function]
                     |  TEMP_INF   =  tinf,              [function]
                     |  TEMP_SUP   =  tsupf,             [function]

               )
```

4.4.3 Operands

/ TEMP =

Value of **temperature** imposed on (S) the node (S) specified (S).

/ For the elements of thermal hull only (Modeling: 'HULL'):

| TEMP_MIL

Temperature on the average layer imposed on (S) the node (S) specified (S).

| TEMP_INF

Temperature imposed on the lower wall of the hull.

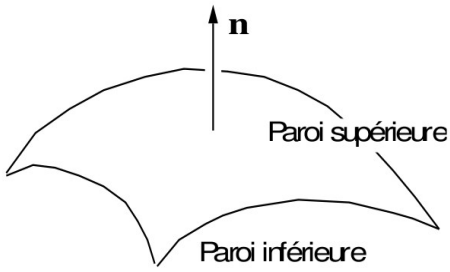
| TEMP_SUP

Temperature imposed on the higher wall of the hull.

These options make it possible to represent a parabolic variation of the temperature in the thickness.

Note:

The hull is directed by the connectivity of the nodes of the associated mesh (cf [U3.01.00]). That is to say n the normal vector directing the hull:



4.5 Keyword FLUX_REP

4.5.1 Goal

Keyword factor usable to apply **normal flows**, with one **face** of voluminal element or thermal hull defined by one or more meshs of the type **triangle** or **quadrangle**. This keyword also makes it possible to apply a normal flow to an edge (in 2D PLAN or AXIS or AXIS_FOURIER) on meshs of type segment.

According to the name of the operator called, the values are provided directly (AFFE_CHAR_THER) or via a concept of the type function (AFFE_CHAR_THER_F).

4.5.2 Syntax

- for AFFE_CHAR_THER

```
 FLUX_REP = _F   (    ♦ /  ALL      =     'YES',
                        /  GROUP_MA =       lgma,            [l_gr_maille]

                     ♦  /  FLUN        =         fl,              [R]
                        /  |  FLUN_INF =      flin,            [R]
                           |  FLUN_SUP =      flsup,           [R]
                 )
```

- for AFFE_CHAR_THER_F

```
FLUX_REP = _F (
                   ♦  /  ALL      =     'YES',
                      /  GROUP_MA =       lgma,            [l_gr_maille]


                   ♦  /  FLUN =              flf,             [function]
                      /  |  FLUN_INF =       flinf,           [function]
                         |  FLUN_SUP =       flsupf,          [function]
                      /  |  FLUX_X   =       flx,             [function]
                         |  FLUX_Y   =       fly,             [function]
                         |  FLUX_Z   =       flz,             [function]
                 )
```

4.5.3 Operands

/ FLUN: fl normal flow imposed on the mesh.

This loading applies to the types of meshs and following modelings:

Mesh	Modeling
TRIA3, TRIA6, QUAD4, QUAD8, QUAD9	3D, 3D_DIAG
SEG2, SEG3	PLAN, AXIS, AXIS_FOURIER, PLAN_DIAG, AXIS_DIAG

More precisely the boundary condition applied is: $\lambda(grad\,T\cdot\boldsymbol{n})$ = fl

where λ is thermal conductivity and $\boldsymbol{n}$ is the normal directed in the direction of the classification of the nodes of the mesh. The convention of orientation is that used in AFFE_CHAR_MECA [U4.44.01].

```
/   |   FLUN_INF = flin
    |   FLUN_SUP = flsup
```

Normal flow imposed on the walls lower and higher of a thermal hull.

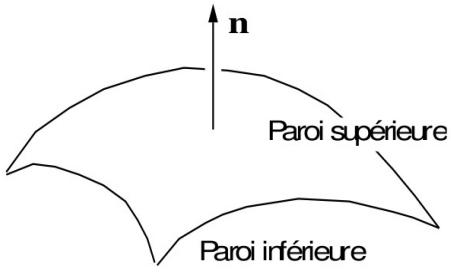
These loadings apply to the types of meshs and following modelings:

Mesh	Modeling
TRIA3, TRIA6	HULL

$\boldsymbol{n}$ being the normal directing surface [U4.44.01], the boundary condition applied is:

$\lambda(grad\,T\cdot\boldsymbol{n})$ = flin where flin is the normal flow imposed on the lower wall of the hull,

$\lambda(grad\,T\cdot\boldsymbol{n})$ = flsup where flsup is the normal flow imposed on the higher wall of the hull.




```
/   |   FLUX_X = flx
    |   FLUX_Y = fly
    |   FLUX_Z = flz
```

Vectorial flow $\boldsymbol{fl}$ in the total reference mark (only for AFFE_CHAR_THER_F) that one projects on the normal with the element (for the definition of the normal [U4.44.01]).

$$\lambda(grad\,T\cdot\boldsymbol{n})=\boldsymbol{fl}\cdot\boldsymbol{n}=flx.nx+fly.ny+flz.nz$$

This loading applies to the types of meshs and modelings:

Mesh	Modeling
TRIA3, TRIA6, QUAD4, QUAD8, QUAD9	3D, 3D_DIAG
SEG2, SEG3	PLAN PLAN_DIAG

Note: the rule of remanence (see U1.03.00) applies between the various quantities which one can affect: FLUN, FLUN_INF,... FLUX_Z.

4.5.4 Notice

The simple keyword CARA_TORSION this keyword factor FLUX_REP is not documented here and does not have to be employed by the user. He is used only for the macro-order MACR_CARA_POUTRE. This one is used to identify the geometrical characteristics of the sections of beams. For the characteristics of torsion, the order solves a problem of Laplacian by employing in an indirect way the operators of linear thermics.

4.6 Keyword FLUX_NL

4.6.1 Goal

Keyword factor usable to apply **normal flows** functions of the temperature, with one **face** of voluminal element defined by one or more meshs of the type **triangle** or **quadrangle**. This keyword also makes it possible to apply a normal flow to an edge (in 2D PLAN or AXIS) on meshs of type segment. One can thus model a condition of radiation of the standard law of Stefan.
This kind of flow is not found that in the order AFFE_CHAR_THER_F and is not used that by the orders THER_NON_LINE [U4.54.02] and THER_NON_LINE_MO [U4.54.03].

The values are provided by a concept of the type function. function depends temperature, other than any other parameter. Moreover, it is necessarily of a tabulée function and not about a formula.

4.6.2 Syntax

- For AFFE_CHAR_THER_F

```
FLUX_NL = _F (
                ♦  /  ALL      =     'YES',
                   /  GROUP_MA =       lgma,            [l_gr_maille]

                ♦     FLUN     =          fl,              [function]
              )
```

4.6.3 Operands

FLUN: normal flow imposed on the mesh.

This loading applies to the types of meshs and following modelings:

Mesh	Modeling
TRIA3, TRIA6, QUAD4, QUAD8, QUAD9	3D, 3D_DIAG
SEG2, SEG3	PLAN, AXIS PLAN_DIAG, AXIS_DIAG

More precisely the boundary condition applied is:

$\lambda\left(grad\,T\cdot\boldsymbol{n}\right)$ = fl

where $\boldsymbol{n}$ is the normal directed in the direction of the classification of the nodes of the mesh. Orientation used in AFFE_CHAR_MECA document [U4.44.01].

4.7 Keyword RADIATION

4.7.1 Goal

Keyword allowing to define the flow radiated ad infinitum according to the formula:

$$\Phi_{ray}=\sigma\,\epsilon\left([T+273,15]^4-[T_\infty+273,15]^4\right)$$

by the data of emissivity ε, the Boltzmann constant σ and the temperature ad infinitum T_∞ expressed into Centigrade. The temperature T will be also expressed into Centigrade, it is thus necessary to take care, by coherence, to use only degrees Celsius for all the study.

4.7.2 Syntax

- for AFFE_CHAR_THER

```
RADIATION = _F   (
                    ♦  /  ALL      =     'YES',
                       /  GROUP_MA =       lgma,           [l_gr_maille]

                     ♦     SIGMA    =       sigma,          [R8]
                     ♦     EPSILON  =       epsilon,        [R8]
                     ♦     TEMP_EXT=        tex,            [R8]
                  )
```

- for AFFE_CHAR_THER_F

```
 RADIATION = _F  (
                    ♦  /  ALL      =     'YES',
                       /  GROUP_MA =       lgma,           [l_gr_maille]

                    ♦     SIGMA    =       sigma,          [function]
                    ♦     EPSILON  =       epsilon,        [function]
                    ♦     TEMP_EXT=        tex,            [function]
                  )
```

4.7.3 Operands

♦ SIGMA = sigma
♦ EPSILON = epsilon
♦ TEMP_EXT = tex

This loading applies to following modelings:

Mesh	Modeling
TRIA3, TRIA6, QUAD4, QUAD8, QUAD9	3D, 3D_DIAG
SEG2, SEG3	PLAN, AXIS PLAN_DIAG, AXIS_DIAG

sigma : Boltzmann constant, $\sigma=5.6710^{-8}$ in units IF ($W/m^2.K^4$) (attention with this value if the units of grid change),
epsilon : emissivity,
tex : temperature ad infinitum in degrees Celsius.

4.8 Keyword EXCHANGE

4.8.1 Goal

Keyword factor usable to apply **conditions of exchange** with an outside temperature with one **face** voluminal elements or hulls, defined by one or more meshs of the type **triangle** or **quadrangle**. This keyword also makes it possible to apply conditions of exchange to an edge (in 2D PLAN or AXIS or AXIS_FOURIER) on meshs of type segment.

According to the name of the operator called, the values are provided directly (AFFE_CHAR_THER) or via a concept of the type function (AFFE_CHAR_THER_F).

4.8.2 Syntax

- for AFFE_CHAR_THER

```
EXCHANGE = _F (
                  ♦  /  ALL      =     'YES',
                     /  GROUP_MA =       lgma,            [l_gr_maille]

                  ♦  /  ♦  COEF_H   =          H,          [R]
                        ♦  TEMP_EXT =          tex,        [R]

                     /  |  ♦  COEF_H_INF   =  hin,         [R]
                           ♦  TEMP_EXT_INF =  texin,       [R]
                        |  ♦  COEF_H_SUP   =  hsup,        [R]
                           ♦  TEMP_EXT_SUP =  texsup,      [R]
                )
```

- for AFFE_CHAR_THER_F

```
EXCHANGE = _F (
                  ♦  /  ALL      =     'YES',
                     /  GROUP_MA =       lgma,            [l_gr_maille]

                  ♦  /  ♦  COEF_H   =          HF,         [function]
                        ♦  TEMP_EXT =          texf,       [function]

                     /  |  ♦  COEF_H_INF   =  hinf,        [function]
                           ♦  TEMP_EXT_INF =  texinf,      [function]
                        |  ♦  COEF_H_SUP   =  hsupf,       [function]
                           ♦  TEMP_EXT_SUP =  texsupf,     [function]
                )
```

4.8.3 Operands

/ ♦ COEF_H = H,
♦ TEMP_EXT = tex,

This loading applies to the types of meshs and following modelings:

Mesh	Modeling
TRIA3, TRIA6, QUAD4, QUAD8, QUAD9	3D, 3D_DIAG
SEG2, SEG3	PLAN, PLAN_DIAG AXIS, AXIS_FOURIER, AXIS_DIAG

More precisely the boundary condition applied is:

$$\lambda(grad\,T\cdot\boldsymbol{n})=h(tex-T)\quad(h>0)$$

where $\boldsymbol{n}$ is the normal directed in the direction of the classification of the nodes tops (orientation used in AFFE_CHAR_MECA [U4.44.01]).

/ | ♦ COEF_H_INF = hin,
♦ TEMP_EXT_INF = texin,
| ♦ COEF_H_SUP = hsup,
♦ TEMP_EXT_SUP = texsup,

This loading applies to the types of meshs and following modelings:

Mesh	Modeling
TRIA3, TRIA6	HULL

$\boldsymbol{n}$ being the normal directing surface [U2.03.03], the boundary condition applied is:

$$\lambda(grad\,T\cdot\boldsymbol{n})=hin(texin-T)$$

where hin and texin: coefficient of exchange on the lower wall of the hull, outside temperature, with dimensions lower wall.

$$\lambda(grad\,T\cdot\boldsymbol{n})=hsup(texsup-T)$$

where hsup and texsup: coefficient of exchange on the higher wall of the hull, outside temperature, with dimensions external wall.

Note:
• the rule of remanence (see U1.03.00) applies between the various quantities which one can affect: COEF_H, COEF_H_INF,... TEMP_EXT_SUP.
• In the case of the loadings functions (AFFE_CHAR_THER_F), as there are two distinct components (the coefficient of exchange and the temperature), which are *a priori* independent, one cannot simultaneously use this loading with a multiplying function in the operator of resolution (THER_LINEAIRE or THER_NON_LINE). An error message will inform you.

4.9 Keyword SOURCE

4.9.1 Goal

Keyword factor usable to apply **voluminal sources** (2D or 3D) with one **field** defined by one or more meshs of the type **voluminal**.

According to the name of the operator called, the values are provided directly (AFFE_CHAR_THER) or via a concept of the type function (AFFE_CHAR_THER_F). This loading accepts functions depending on the variables of order.

4.9.2 Syntax

- for AFFE_CHAR_THER

```
SOURCE=_F (
                  ♦  /  ALL       =     'YES',
                     /  GROUP_MA =       lgma,            [l_gr_maille]

                   ♦ ..... /   SOUR          =         S,     [R]
                     /  SOUR_CALCULEE =        chs,   [cham_elem]
          )
```

- for AFFE_CHAR_THER_F

```
SOURCE=_F (
               ♦  /  ALL       =     'YES',
                  /  GROUP_MA =       lgma,            [l_gr_maille]

               ♦  SOUR         =          sf,           [function]
          )
```

4.9.3 Operands

This loading applies to the types of meshs and following modelings:

Mesh	Modeling
HEX A8, HEXA20, HEXA27 PYRA5, PYRA13, PENTA6, PENTA15 TETRA4, TETRA10	3D, 3D_DIAG
TRIA3, TRIA6, QUAD4, QUAD8, QUAD9	PLAN, PLAN_DIAG, AXIS, AXIS_FOURIER AXIS_DIAG

/ ♦ SOUR = S,

Value of the presumedly constant source on the element.

/ ♦ SOUR_CALCULEE = chs,

Name of cham_elem_sour_R containing on each element the values of the source discretized at the points of Gauss (1era family).

4.10 Keyword PRE_GRAD_TEMP

4.10.1 Goal

Keyword factor usable to apply to an element 3D or 2D (PLAN, AXIS) a presumedly uniform variation in temperature in the element. This "initial" variation in temperature is usable for example to solve the elementary problems determining the correctors of stationary linear thermics in the basic cell (2D, 3D), in periodic homogenisation.

The coefficients of homogenized conductibility are obtained while calculating by the operator POST_ELEM [U4.81.22] keyword ENER_POT the energy dissipated thermically with balance in linear thermics starting from the correctors.

Because of the thermal analogy, this approach can be exploited to obtain the correctors in elasticity antiplane in the basic cell 2D, as well as in electric conduction.

Calculation uses the conductivity of material. This one is supposed to be isotropic and independent of the temperature.

The assignment can be done on one or more meshs or on all the elements of the model.

4.10.2 Syntax

- for AFFE_CHAR_THER

```
PRE_GRAD_TEMP = _F  (
                  ♦  /  ALL      =     'YES',
                     /  GROUP_MA =       lgma,            [l_gr_maille]

                  ♦  |  FLUX_X =         flx,               [R]
                     |  FLUX_Y =         fly,               [R]
                     |  FLUX_Z =         flz,               [R]
                     )
```

4.10.3 Operands

This loading applies to the types of meshs and following modelings:

Mesh	Modeling
TRIA3, TRIA6, QUAD4, QUAD8, QUAD9	PLAN, AXIS, PLAN_DIAG, AXIS_DIAG
HEXA8, HEXA20, HEXA27 PENTA6, PENTA15, TETRA4, TETRA10 PYRA5, PYRA13	3D, 3D_DIAG

♦ | FLUX_X = flx (flxf)
| FLUX_Y = fly (flyf)
| FLUX_Z = flz (flzf) (in 3D only)

Components of the variation in temperature $grad\,T_{ini}$ in the total reference mark.

The second calculated elementary member is: $\int_{V_e} grad\,T_{ini}\,K\,grad\,T^{*}\,dV_e$ where K is the tensor of thermal conductivities.

The gradients can be a function of the geometry and/or time.

- for AFFE_CHAR_THER_F

```
PRE_GRAD_TEMP = _F  (
                    ♦  /  ALL      =     'YES',
                       /  GROUP_MA =       lgma,            [l_gr_maille]

                       ♦  |  FLUX_X =         flxf,         [function]
                          |  FLUX_Y =         flyf,         [function]
                          |  FLUX_Z =         flzf,         [function]
                    )
```

4.11 Keyword LIAISON_DDL

4.11.1 Goal

Keyword factor usable to define a linear relation between degrees of freedom of two or several nodes.

According to the name of the operator called, the values are provided directly (AFFE_CHAR_THER) or via a concept function (AFFE_CHAR_THER_F).

4.11.2 Syntax

- for AFFE_CHAR_THER

```
LIAISON_DDL = _F (♦ GROUP_NO =       lgno,            [l_gr_noeud]

                  ◊ DDL =      |            'TEMP',       [DEFECT]
                               |            'TEMP_MIL',
                               |            'TEMP_INF',
                               |            'TEMP_SUP',
                               |            'H1',

                  ♦ COEF_MULT =             hasI  ,          [l_R]
                  ♦ COEF_IMPO =             B  ,         [R]
                )
```

- for AFFE_CHAR_THER_F

```
LIAISON_DDL = _F (  ♦  GROUP_NO =       lgno,         [l_gr_noeud]

                  ◊ DDL =      |            'TEMP',       [DEFECT]
                               |            'TEMP_MIL',
                               |            'TEMP_INF',
                               |            'TEMP_SUP',
                               |            'H1',

                  ♦  COEF_MULT =            hasI   ,         [l_R]
                  ♦  COEF_IMPO =            BF  ,         [function]
                )
```

4.11.3 Operands

The list of the nodes N_i ($i=1,r$) defined by GROUP_NO is ordered in a natural way, i.e. in the order of the list of group of nodes, and for each group of nodes, in the order of definition of the group by GROUP_NO.

The argument of DDL must be a list of degrees of freedom T_i ($i=1,r$) of r texts taken among: 'TEMP', 'TEMP_MIL', 'TEMP_SUP', 'TEMP_INF', 'H1'

If the keyword DDL is omitted, by default the linear relation will relate to the degrees of freedom 'TEMP'.

The argument of COEF_MULT must be a list a_i ($i=1,r$) coefficients (of real type for AFFE_CHAR_THER and AFFE_CHAR_THER_F).

The argument of COEF_IMPO is a coefficient β for AFFE_CHAR_THER, a function of space for AFFE_CHAR_THER_F.

The following kinematic condition is applied: $\sum_{i=1}^{r} \alpha_i T_i = \beta$

Note:

*Components 'TEMP_MIL', 'TEMP_SUP' and 'TEMP_INF' can intervene only in affected combinations **only** with nodes which belong to elements of **hull** (modeling 'HULL').*

*The component 'H1' can intervene only in affected combinations **only** with nodes which belong to elements **X-FEM**. In this case, only degrees of freedom 'TEMP' and 'H1' can appear in the linear relation.*

*In the case of a linear relation between the degrees of freedom of the same node, one will repeat behind the keyword GROUPE_NO the name of group defining it node as many times as there are degrees of freedom in the relation. **Example:** to impose $T_{\sup} = T_{\inf}$ on the node of group $GN1$, one will write:*

```
LIAISON_DDL = _F (  GROUP_NO  =  (GN1,GN1),
                    DDL       =  ('TEMP_SUP', 'TEMP_INF'),
                    COEF_MULT =  (1. , - 1.),
                    COEF_IMPO =  0. ,
                  )
```

It is important to note that with an occurrence of the keyword factor LIAISON_DDL corresponds one and only one linear relation.
*If one wants to impose the same relation between 2 groups of nodes GRN01 and GRN02 (even temperature node with node for example) **one cannot write:***

```
LIAISON_DDL = _F    ( GROUP_NO  =  (GRN01, GRN02),
                      DDL       =  ('TEMP',  'TEMP'),
                    COEF_MULT =  (1. , - 1.),
                    COEF_IMPO =  0. ,                          )
```

This writing has direction only if GRN01 and GRN02 contain each one one node. It will be necessary in the case to clarify each linear relation above, node by node.

The keyword LIAISON_GROUP on the other hand allows to condense the writing of the linear relations between 2 groups of nodes in opposite.

4.12 Keyword LIAISON_GROUP

4.12.1 Goal

Keyword factor usable to define linear relations between couples of nodes, these couples of nodes being obtained while putting in opposite two lists of meshs or nodes.

According to the name of the operator called N, the values are provided directly (AFFE_CHAR_THER) or via a concept function (AFFE_CHAR_THER_F).

4.12.2 Syntax

- for AFFE_CHAR_THER

```
LIAISON_GROUP=_F (  ♦  /  ♦  GROUP_MA_1    =  lgma1, [l_gr_maille]
                          ♦  GROUP_MA_2    =  lgma2, [l_gr_maille]
                       /  ♦  GROUP_NO_1    =  lgno1, [l_gr_noeud]
                          ♦  GROUP_NO_2    =  lgno2, [l_gr_noeud]
                    ◊  SANS_GROUP_NO       =  lgno,  [l_gr_noeud]
                     ◊  DDL_1 =   |     'TEMP',          [DEFECT]
                                  |     'TEMP_MIL',
                                  |     'TEMP_INF',
                                  |     'TEMP_SUP',
                                  |     'H1',
                     ◊  DDL_2 =   |     'TEMP',          [DEFECT]
                                  |     'TEMP_MIL',
                                  |     'TEMP_INF',
                                  |     'TEMP_SUP',
                                  |     'H1',
                     ♦  COEF_MULT_1 =     has1i  ,          [l_R]
                     ♦  COEF_MULT_2 =     has2i  ,          [l_R]
                     ♦  COEF_IMPO      =  B   ,          [R]
                    ◊  |  CENTER    =  Lr  ,          [l_R]
                       |  ANGL_NAUT =  Lr  ,          [l_R]
                       |  TRAN      =  Lr  ,          [l_R]
                )
```

- for AFFE_CHAR_THER_F

```
LIAISON_GROUP=_F (  ♦  /  ♦  GROUP_MA_1    =  lgma1, [l_gr_maille]
                          ♦  GROUP_MA_2    =  lgma2, [l_gr_maille]
                       /  ♦  GROUP_NO_1    =  lgno1, [l_gr_noeud]
                          ♦  GROUP_NO_2    =  lgno2, [l_gr_noeud]
                    ◊  SANS_GROUP_NO       =  lgno,  [l_gr_noeud]
                     ◊  DDL_1 =   |     'TEMP',          [DEFECT]
                                  |     'TEMP_MIL',
                                  |     'TEMP_INF',
                                  |     'TEMP_SUP',
                                  |     'H1',
                     ◊  DDL_2 =   |     'TEMP',          [DEFECT]
                                  |     'TEMP_MIL',
                                  |     'TEMP_INF',
                                  |     'TEMP_SUP',
                                  |     'H1',
                    ♦   COEF_MULT_1 =   has1i ,          [l_R]
                    ♦   COEF_MULT_2 =   has2i ,          [l_R]
                    ♦  COEF_IMPO    =   BF,              [function]
                    ◊  |  CENTER    =  Lr ,              [l_R]
                       |  ANGL_NAUT =  Lr ,              [l_R]
                       |  TRAN      =  Lr ,              [l_R]
                )
```

4.12.3 Operands

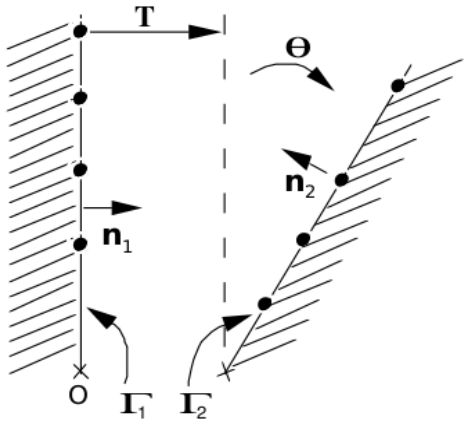


Figure 4.11.3-a: Geometrical transformation of a border in another

Kinematic condition “general”: $\sum_{i=1}^{NDDL1} \alpha_{1i} T_i\big|_{\Gamma_1} + \sum_{i=1}^{NDDL2} \alpha_{2i} T_i\big|_{\Gamma_2} = \beta$

/ ♦ GROUP_MA_1 =

Ittte operand definiteT Γ_1 via the meshs which compose it.

♦ GROUP_MA_2 =

Ittte operand definiteT Γ_2 via the meshs which compose it.

/ ♦ GROUP_NO_1 =

Ittte operand definiteT Γ_1 via the nodes which compose it.

♦ GROUP_NO_2 =

Ittte operand definiteT Γ_2 via the nodes which compose it.

◊ SANS_GROUP_NO =

Ittte operand makes it possible to remove list of the couples of nodes out of screw - with - screw all the couples of which at least one of the nodes belongs to the list of nodes data.

That makes it possible to avoid the accumulation of linear relations on the same node during various iterations on the keyword factor LIAISON_GROUP what leads most of the time to a singular matrix.

♦ COEF_MULT_1 (resp. COEF_MULT_2)

List of realities dimensioned exactly with the number of degrees of freedom declared in DDL_1 (resp. DDL_2) corresponding to the multiplying coefficients of the linear relation.

♦ COEF_IMPO: coefficient of blocking of the linear relation:

β : reality for AFFE_CHAR_THER
β_f : function for AFFE_CHAR_THER_F

◊ CENTER : coordinates of the centre of rotation
◊ ANGL_NAUT : nautical angles in degrees defining rotation (see AFFE_CARA_ELEM [U4.42.01] keyword ORIENTATION)
◊ TRAN : components of the vector translation

These operands make it possible to define a virtual transformation (rotation and/or translation) approximate of Γ_1 in Γ_2 in order to ensure the bijectivity of the function opposite.

◊ DDL_1 (resp. DDL_2):

List of texts taken among:
'TEMP', 'TEMP_MIL', 'TEMP_INF', 'TEMP_SUP', 'H1'

'TEMP_MIL', 'TEMP_INF' and 'TEMP_SUP' can be used only for elements of thermal hull (modeling: 'HULL').

'H1' can be used only for elements X-FEM. In this case, only degrees of freedom 'TEMP' and 'H1' can appear in the linear relations.

By default, the degree of freedom considered for all the nodes of the linear relations is 'TEMP'.

4.12.4 Use of LIAISON_GROUP

- LIAISON_GROUP generate linear relations only between 2 nodes (one on Γ_1, one on Γ_2)

  To generate linear relations on more than 2 nodes, to use the keyword LIAISON_DDL.

- determination of the couples of nodes in opposite:

  initially, one draws up the two lists of nodes to be put in opposite (IE to be paired), for each occurrence of the keyword factor LIAISON_GROUP :

  - for the keywords GROUP_NO_1 and GROUP_NO_2, they are the nodes setting up the groups of nodes,
  - for the keywords GROUP_MA_1 and GROUP_MA_2, they are the nodes of the meshs setting up the groups of meshs.

  The redundancies being eliminated, the two lists of nodes obtained must have the same length.

  The determination of the couples of nodes in opposite is done in several stages:

  - for each node $N1$ first list, one seeks the node image $N2=f(N1)$ second list. If F is not injective (a node $N2$ is the image of two distinct nodes $N1$ and $N1'$), the following error message is transmitted:

    ```
    <F> <AFFE_CHAR_THER> <PACOAP> CONFLICT IN OPPOSITE
    NODES
    THE NODE N2 IS IT WITH RESPECT TO THE NODES N1 AND N1'
    ```

  - for each node $N2$ second list, one seeks the node image $N1=g(N2)$ first list. If G is not injective (a node $N1$ is the image of two distinct nodes $N2$ and $N2'$), the following error message is transmitted:

    ```
    <F> <AFFE_CHAR_MECA> <PACOAP> CONFLICT IN OPPOSITE
    NODES
    THE N1 NODE IS IT WITH RESPECT TO THE NODES N2 AND N2'
    ```

  - it is checked that $g=f^{-1}$, i.e. the couples obtained by the stages a) and b) are the same ones (one wants to have a bijection f between the two lists of nodes). If F is not surjective, the following error message is transmitted:

    ```
    <F> <AFFE_CHAR_MECA> <PACOAP> CONFLICT IN OPPOSITE GENERATE
    SUCCESSIVELY FROM LISTS LIST1 AND LIST2
    THE NODE OF THE FIRST N1 LIST IS NOT THE IMAGE OF ANY NODE BY
    OPPOSITE CORRESPONDENCE
    ```

  For a node N given, node image is called $f(N)$ the node of the other list of nodes which carries out the minimum of distance with N. To facilitate pairing, in particular in the case of particular geometries (where borders Γ_1 and Γ_2 could “almost” result one from the other by the composition of a translation and of a rotation), one gives the opportunity of making a virtual geometrical transformation of the first group of nodes (translation and rotation (cf [Figure 4.11.3-a]) before calculating the distances (keywords TRAN, CENTER and ANGL_NAUT).

  For each occurrence of the keyword factor LIAISON_GROUP, one thus builds the list of the new couples in opposite. When all the occurrences were swept, one removes list the couples in double.

Note:

In the couples of nodes in opposite, the order of the nodes is important. So for the first occurrence of `LIAISON_GROUP` *, a node* N *belonged to the first group of nodes and a node* M *with the second group of nodes, and that for the second occurrence of* `LIAISON_GROUP` *, it is the reverse, one will obtain at the conclusion of pairing the couples* (N,M) *and* (M,N) *. They will not be eliminated during detection of the redundancies; on the other hand, the matrix obtained will be singular. Thus, one advises to keep same logic during the description of the edges out of screw - with - screw.*

4.13 Keyword LIAISON_MAIL

4.13.1 Goal

Keyword factor allowing “to thermically restick” two edges of a structure. These edges can be with a grid differently (incompatible grids) but must result one from the other by rotation and/or translation.

4.13.2 Syntax

- in AFFE_CHAR_THER only

```
LIAISON_MAIL =_F (  ♦  GROUP_MA_MAIT =        lgma_mait,

                    ♦  |  GROUP_MA_ESCL =        lgma_escl,
                       |  GROUP_NO_ESCL =        lgno_escl,

                    ◊     DISTANCE_MAX   =      d_max,        [R]

                    ◊  |  ♦  TRAN    =     (tx, ty, [tz]),         [l_R]
                       |  ♦  CENTER =     (xc, yc, [zc]),         [l_R]
                          ♦  ANGL_NAUT =  (alpha, [beta, gamma]),[l_R]
                  )
```

Face 1 is called face “Master”; face 2 is called face “slave”.

4.13.3 Operands

4.13.3.1 GROUP_MA_ESCL / GROUP_NO_ESCL

These keywords make it possible to define the whole of the nodes of the face slave. One takes all the nodes specified by the keyword GROUP_NO_ESCL more possibly nodes carried by the meshs specified by the keyword GROUP_MA_ESCL.

4.13.3.2 GROUP_MA_MAIT

This keyword makes it possible to define the whole of the meshs where they with respect to the nodes of the face slave will be sought.

One should not give the meshs of surface (in 3D) composing the adjacent face Master, but voluminal meshs with the face Master. The specified meshs are candidates for the research of opposite. One can give too much of it.

4.13.3.3 DISTANCE_MAX

To project the grid $MA1$ on the grid $MA2$, the method seeks in which element of the grid $MA1$ each node is of $MA2$, then the value using the functions of form of the element interpolates. When that a node of $MA2$ is not in any element of the grid $MA1$, the method connects the node and the point (of the edge) of the element nearest. It interpolates the value using the functions of form of the element and that even if the node is "far" from this element.

If it be wished that a node which is not in any the elements of the grid $MA1$, is not concerned with projection, one uses the operand DISTANCE_MAX. This operand makes it possible to give the maximum distance which one authorizes between the node and the element nearest.

If the node does not answer the criterion of proximity the field will not be project on this node (i.e the node will not carry any component).

There is no value by default for DISTANCE_MAX. What wants to say that by default, the field will be prolonged apart from the matter also far one will need it.

4.13.3.4 DISTANCE_ALARME = d_ala

The code emits an alarm when a node of $MA2$ is considered to be "distant" from the meshs from $MA1$.
That is to say D the distance separating a node of $MA2$ mesh of $MA1$ nearest.
By default, the criterion to judge if a node is distant is relative:
D > 1/10 ème of the size of the mesh nearest.
But if the user uses DISTANCE_ALARME = d_ala, the message of alarm is transmitted if D > d_ala (absolute criterion).

4.13.3.5 CENTER / ANGL_NAUT / TRAN

These operands make it possible to define the geometrical transformation (rotation and/or translation) making it possible to pass from the face main slave to the face. The order carries out initially rotation then the translation.

Caution: the transformation is in the direction slave-Master.

This boundary condition applies to plane modelings ('PLAN' or 'AXIS') or voluminal ('3D').

4.14 Keyword ECHANGE_PAROI

4.14.1 Goal

Keyword factor usable to apply conditions of heat exchange between 2 walls. These walls can be defined in two manners:

- each one separately, by one or more meshs (case of walls with a grid);
- starting from a list of cracks X-FEM, two walls corresponding then to the two lips of each crack. In this case it is also possible to impose the continuity of the field of température through the lips of each crack.

4.14.2 Syntax

- for AFFE_CHAR_THER

```
ECHANGE_PAROI=_F (
```

```
                        # if the wall is with a grid
                        ♦  GROUP_MA_1 =        lgma,     [l_gr_maille]
                        ♦  GROUP_MA_2 =        lgma,     [l_gr_maille]
                        ♦     COEF_H =           H,        [R]
                        ◊     TRAN =             Lr,       [l_R]

                        # if the wall is defined with cracks X-FEM
                        ♦     CRACK =            lfiss,    [l_fiss_xfem]
                        ♦  /  COEF_H =           H,        [R]
                           /  TEMP_CONTINUE =    'YES'
                    )
```

- for AFFE_CHAR_THER_F

```
ECHANGE_PAROI=_F (
                        # if the wall is with a grid
                        ♦  GROUP_MA_1 =        lgma,     [l_gr_maille]
                        ♦  GROUP_MA_2 =        lgma,     [l_gr_maille]
                        ♦     COEF_H =           H,        [function]
                        ◊     TRAN =             Lr,       [l_R]

                        # if the wall is defined with cracks X-FEM
                        ♦     CRACK =            lfiss,    [l_fiss_xfem]
                        ♦  /  COEF_H =           H,        [function]
                           /  TEMP_CONTINUE =    'YES'
                    )
```

4.14.3 Operands

4.14.3.1 Case of walls with a grid

♦ COEF_H

Coefficient of exchange enters the 2 walls.
Reality for the operator AFFE_CHAR_THER, function for the operator AFFE_CHAR_THER_F.

♦ GROUP_MA_1

♦ GROUP_MA_2

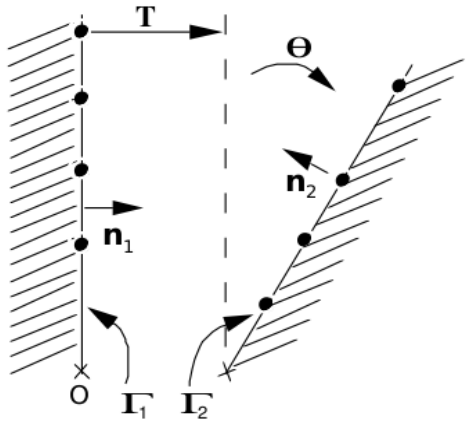


Figure 4.13.3-a

These operands make it possible to define the 2 lists of meshs representing for the subscripted list "_1" the wall Γ_1 for the subscripted list "_2" the wall Γ_2.

The walls are in correspondence and must comprise the same number of meshs and nodes.

The limiting condition applied between these 2 walls is:

on Γ_1 : $k\frac{\partial T_1}{\partial n_1}=h\left(T_2-T_1\right)$ n_1 normal external with Γ_1

on Γ_2 : $k\frac{\partial T_2}{\partial n_2}=h\left(T_1-T_2\right)$ n_2 normal external with Γ_2

where $\begin{array}{ll} T_1|_{\Gamma_1}=T & T_2|_{\Gamma_1}=T\circ f \\ T_1|_{\Gamma_2}=T\circ f^{-1} & T_2|_{\Gamma_2}=T \end{array}$

f representing the bijection which puts in opposite a node of Γ_1 and a node of Γ_2.

◊ TRAN

Components of the vector translation.
This operand makes it possible to define a virtual transformation (translation) approximate of Γ_1 in Γ_2 in order to ensure the bijectivity of the function out of screw - - screw. TRAN characterize a translation:

in 2D one thus has : TRAN = (tx, ty)
in 3D one has : TRAN = (tx, ty, tz)

4.14.3.2 Case of one or more cracks X-FEM

♦ CRACK

List of cracks X-FEM.
For each crack given in this list, the two walls in opposite are defined like the upper lip and the lower lip of the crack. There is thus as much couple of walls in opposite than of cracks present in this list.

♦ / COEF_H

Coefficient of exchange enters the lips of the crack. Reality for the operator AFFE_CHAR_THER , function for the operator AFFE_CHAR_THER_F .
If this keyword is present, the condition of exchange imposed between the lips of each crack given under the keyword CRACK is same as in the case of wall with a grid (see § preceding), while taking identitié for the bijection f since the upper lips and lower of each crack are geometrically confused.

/ TEMP_CONTINUE

This keyword can be indicated only with the value 'YES'.
If this keyword is present, one imposes the continuity of the field of temperature through the lips of each crack given under the keyword CRACK, by cancelling the degrees of freedom of enrichment (“Heaviside” and “ace-tip”).

4.14.4 Use of ECHANGE_PAROI

In the case of a wall with a grid:

The user gives two lists of meshs from which the couples from paired nodes will result. These lists are initially sorted by type of mesh: the paired nodes will come from meshs of the identical type. For each mesh of the first list, one determines the mesh nearest in the second list by calculating all the distances from the nodes taken two to two (one traverses all the possible permutations). The distance minimum obtained defines at the same time the mesh in opposite and the couples of nodes paired for the two meshs concerned. As in LIAISON_GROUP [§4.11], it is possible to carry out a virtual geometrical transformation (rotation and/or translation) before calculating the distances.

In the case of one or several cracks X-FEM:

One defines as many couples of walls in opposite than there are cracks in the list indicated for the keyword CRACK.

- If the keyword COEF_H is present, all the cracks contained in this list will see affected the same coefficient of exchange (real or function). To assign a value of the clean coefficient of exchange to each crack, it is necessary to use the character répétable keyword factor ECHANGE_PAROI.
- If the keyword TEMP_CONTINUE is present, one imposes the continuity of the field of temperature through all the cracks contained in this list.

4.14.1 Meshs and modelings supporting this loading:

In the case of walls with a grid:

The lists of meshs given by the user must be made up of meshs of edge, of the meshs of coupling then are automatically generated. The table below provides a summary of the meshs of edges as of modelings for which this kind of loading is supported.

Mesh of edge	Modeling	Mesh of coupling generated

SEG2, SEG3	PLAN, PLAN_DIAG AXIS, AXIS_DIAG	SEG22, SEG33
TRIA3, TRIA6, QUAD4, QUAD8, QUAD9	3D, 3D_DIAG	TRIA33, TRIA66, QUAD44, QUAD88, QUAD99

In the case of one or several cracks X-FEM:

The cracks must be created with the operator beforehand DEFI_FISS_XFEM [U4.82.08], and the model (well informed for the keyword MODEL) with the operator MODI_MODELE_XFEM [U4.41.11], which is not possible that in the following cases:

- modeling 3D for the meshs support HEXA8, PENTA6, PYRA5, TETRA4
- modelings PLAN and AXI for the meshs support QUAD4 and TRIA3

4.15 Keyword LIAISON_UNIF

4.15.1 Goal

Keyword factor allowing to impose the same value (unknown) on the temperatures of a set of nodes.

These nodes are defined by the groups of meshs or groups of nodes to which they belong.

4.15.2 Syntax

- for AFFE_CHAR_THER and AFFE_CHAR_THER_F

```
LIAISON_UNIF =_F (
                    ♦  /  GROUP_MA  =  lgma,            [l_gr_maille]
                       /  GROUP_NO  =  lgno,            [l_gr_noeud]

                     ♦  DDL = |  'TEMP' ,               [DEFECT]
                              |  'TEMP_MIL',
                              |  'TEMP_INF',
                              |  'TEMP_SUP',
                  )
```

4.15.3 Operands

♦ / GROUP_MA
/ GROUP_NO

These operands make it possible to define a list of n nodes N_i from which one eliminated the redundancies (for GROUP_MA, it is connectivities of the meshs).

♦ DDL

This operand makes it possible to define a list of degrees of freedom $T_i(i=1,r)$ of r texts taken among: 'TEMP', 'TEMP_MIL', 'TEMP_INF', 'TEMP_SUP'.

$r\times(n-1)$ conditions 'kinematics' resulting are:

$T_i(N_1)=T_i(N_k)$ for $k\in(2,\dots,n)$, $i\in(1,\dots,r)$

Note:

Components 'TEMP_MIL' , 'TEMP_SUP' , 'TEMP_INF' can intervene only for nodes of elements of hull.

4.16 Keyword LIAISON_CHAMNO

4.16.1 Goal

Keyword factor usable to define a linear relation between all the temperatures present in a concept CHAM_NO.

4.16.2 Syntax

```
LIAISON_CHAMNO = _F (  ♦  CHAM_NO   =  chamno,              [cham_no]
                       ♦  COEF_IMPO =   B,                  [R]
                       ◊  NUME_LAGR =  /   'NORMAL',        [DEFECT]
                                       /   'AFTER',
                    )
```

4.16.3 Operands

CHAM_NO =

Name of chamno who is used to define the linear relation. The temperatures connected are all those present in chamno. The coefficients to be applied to the temperatures are the values of these temperatures in chamno.

Example:

Let us suppose that one has one chamno relating to 3 nodes of names $N01$, $N02$ and $N03$.

Let us suppose that the values of the temperatures in these 3 nodes in chamno are respectively 2. , 5.4 and 9.1. The linear relation that one will impose is:
$2.T(NO1)+5.4T(NO2)+9.1T(NO3)=\beta$

COEF_IMPO =

It is the value of the real coefficient β with the second member of the linear relation.

NUME_LAGR =

If 'NORMAL', the 2 multipliers of Lagrange associated with the relation will be such as the first will be located before all the terms implied in the relation and the second after, in the assembled matrix.

If 'AFTER', the 2 multipliers of Lagrange associated with the relation will be located after all the terms implied in the relation, in the assembled matrix.

This choice has the advantage of having an assembled matrix whose obstruction is weaker but has the disadvantage to be able to reveal a singularity in the matrix.

4.17 Keyword CONVECTION

4.17.1 Goal

Keyword usable to take into account the term of transport of heat by convection whose expression is $\rho C_p . V\ grad\ T$, appearing in the expression of the particulate derivative $\rho C_p \frac{dT}{dt} : \rho C_p \frac{dT}{dt} = \rho C_p \frac{\partial T}{\partial t} + \rho C_p V\ grad\ T$.

In the case of a liquid medium, V indicate the speed imposed of the fluid particle on the current point.

In the case of a mobile solid medium, V indicate the speed of the solid. In all the cases, it is supposed that the field speed is known a priori. The case of a mobile solid is rather frequent in practice. It relates to in particular the applications of welding or surface treatment which bring into play a source of heat moving in a given direction and at a speed.

The thermal problem is then studied in a reference frame related to the source (cf. THER_NON_LINE_MO [U4.54.03]).

4.17.2 Syntax

```
CONVECTION = _F  (  ♦  SPEED   = v                [cham_no_sdaster])
```

4.17.3 Operand

For AFFE_CHAR_THER and AFFE_CHAR_THER_F,

SPEED =

Name of the field speed at the moment when calculation is carried out.

This field is a concept cham_no of type cham_no_depl_r. It must have been defined on all the model for which one carries out calculation.

4.18 Keyword SOUR_NL

4.18.1 Goal

Keyword factor usable to apply **voluminal sources depending on the temperature** (2D or 3D) with one **field** defined by one or more meshs of the type **voluminal**.
This kind of flow is not found that in the order AFFE_CHAR_THER_F and is not used that by the orders THER_NON_LINE [U4.54.02] and THER_NON_LINE_MO [U4.54.03].

The values are provided by a concept of the type function. function depends temperature, other than any other parameter. Moreover, it is necessarily of a tabulée function and not about a formula.

4.18.2 Syntax

```
SOUR_NL=_F    (
                ♦  /  ALL      =        'YES',
                   /  GROUP_MA =          lgma,          [l_gr_maille]

                ♦  SOUR        =          sf,           [function]
              )
```

4.18.3 Operands

This loading applies to the types of meshs and following modelings:

Mesh	Modeling
HEX A8, HEXA20, HEXA27 PYRA5, PYRA13, PENTA6, PENTA15 TETRA4, TETRA10	3D
TRIA3, TRIA6, QUAD4, QUAD8, QUAD9	PLAN, AXIS
HEX A8, PYRA5, PENTA6, TETRA4	3D_DIAG
TRIA3, QUAD4	PLAN_DIAG, AXIS_DIAG

/ ♦ SOUR = S,

Value of the source depending on the temperature and presumedly constant on the element.

4.19 Keyword EVOL_CHAR

EVOL_CHAR = evch

The keyword factor EVOL_CHAR is usable to apply evolutionary loadings in the time of the type evol_char products by LIRE_RESU [U7.02.01] or CREA_RESU [U4.44.12] and containing fields of coefficients corresponding that is to say:

- with a loading of the type EXCHANGE (see § 4.8): the field T_EXT corresponds to the parameter TEMP_EXT and the field COEF_H corresponds to the parameter COEF_H .
- with a loading of the type FLUX_REP (see § 4.5): the field FLUN corresponds to the parameter of the same name.