
Operator CALC_MATR_AJOU

1 Goal

To calculate matrices of mass [R4.07.03], damping or rigidity added.

The matrices are induced by a fluid true, incompressible, at rest or in potential flow, on a structure in 2D, 2D axisymmetric or in 3D.

The terms of these matrices are calculated on the basis of modal structure in the vacuum.

The calculation of the terms of the matrices is carried out by resolution of the equations of LAPLACE within the framework of one **thermal analogy**. The calculated temperature plays the part of a pressure in the fluid field. Care thus should be taken to define fluid material by characteristics **thermics**, and to affect a model **thermics** with the part of the grid which represents the fluid.

Thanks to this operator, one can determine for example, the added matrices of a tube bundle, regarded as only one structure immersed in the same fluid.

Within the framework of a calculation by dynamic under-structuring, it is also possible to evaluate the matrix of mass added on a generalized model.

For systematic uses of this order and to simplify the drafting of the command file, one will use the macro-order effectively `MACRO_MATR_AJOU` [U4.66.11].

Product a structure of data of the type `matr_asse_gene_R`.

The cas-tests according to present examples of use of this operator:

- FDLV100 [V8.01.100],
- FDLV101 [V8.01.101],
- FDLV102 [V8.01.102],
- FDLV103 [V8.01.103],
- FDLV104 [V8.01.104],
- FDLV105 [V8.01.105],
- FDLV106 [V8.01.106],
- FDLV107 [V8.01.107],
- FDLV109 [V8.01.109],

- FDLV110 [V8.01.110].

2 Syntax

```
massaj [matr_asse_gene_R] = CALC_MATR_AJOU

(
  ◆ MODELE_FLUIDE = fluid [model]
  ◆ MODELE_INTERFACE = interf [model]
  ◆ CHAM_MATER = matflui [cham_mater]
  ◆ LOAD = load [char_ther]
  ◆ / MODE_MECA = modes [mode_meca]
    / CHAM_NO = chamno [cham_no_DEPL_R]
    / MODELE_GENE = modgen [modele_gene]

  If CHAM_NO
    ◇ NUME_DDL_GENE = numgen [nume_ddl_gene]

  If MODE_MECA or MODELE_GENE
    ◆ NUME_DDL_GENE = numgen [nume_ddl_gene]

  ◇ DIST_REFE = / distance [R]
                / 1.E-2 [DEFECT]
  ◇ AVEC_MODE_STAT = / 'YES' [DEFECT]
                    / 'NOT'
  ◇ NUME_MODE_MECA = digital [1_I]
  ◇ INFORMATION = / 1 [DEFECT]
                  / 2

  ◆ OPTION = | 'MASS_AJOU'
              | 'AMOR_AJOU'
              | 'RIGI_AJOU'
  ◇ POTENTIAL = phi [evol_ther]
  ◇ SOLVEUR = to see [U4.50.01]

  ◇ NOEUD_DOUBLE = / 'YES'
                  / 'NOT' [DEFECT]
);
```

3 Operands

3.1 Operand MODELE_FLUIDE

- ◆ `MODELE_FLUIDE = fluid`

Model **thermics** that one assigns to the part of the grid which corresponds to the fluid. The elements of edge to the fluid interface/structure must be present in the fluid model. It is on this model that one solves the equation of Laplace with boundary condition of type "fluid flow", to have the field of pressure in all the fluid and a *fortiori* the field of pressure to the fluid interface/structure.

The nodes of the elements of the fluid grid must all be numbered so that the jacobien of the element is of positive sign on all the fluid grid.

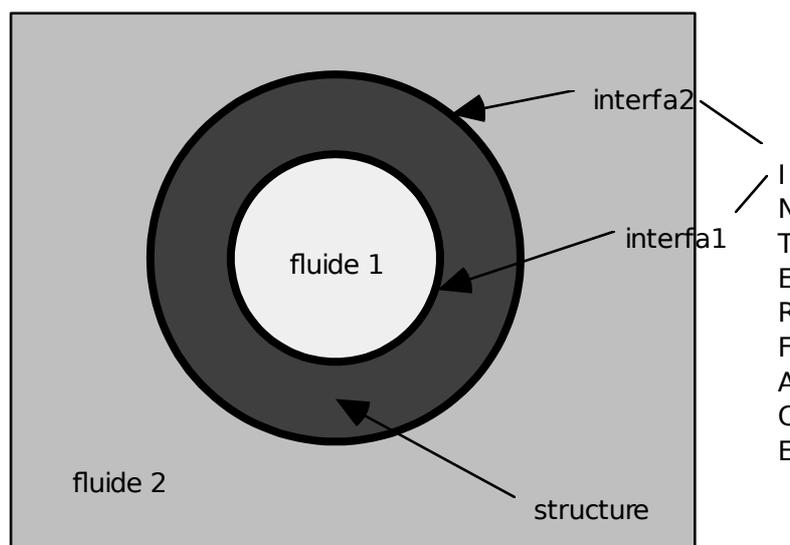
3.2 Operand MODELE_INTERFACE

- ◆ `MODELE_INTERFACE = interf`

Model **thermics** of interface gathering all the elements of edge defining the fluid interface/structure. It is on this model that one calculates the terms of the added matrices.

Calculation depends on **orientation** normal of these elements of interface. It should be taken care that this normal is directed towards **all** these elements, from the structure towards the fluid (adopted convention).

If the fluids bathing the structure are different densities, the model should be defined interfaces per as many groups of meshes not confused geometrically than there are fluids in contact with the structure. For example, a piping can have its interior surface in contact with a fluid of density 1, and its surface external in contact with a fluid of density 2. The model interface is thus built on two groups of meshes not confused geometrically, one in contact with the fluid of density 1 (`interfa1`) and the other in contact with the fluid of density 2 (`interfa2`).



3.3 Operands CHAM_MATER / LOAD

- ◆ CHAM_MATER = matflui

Material field defining the fluid immersing the structure. This material is defined by characteristics **thermics** equivalent in the operator `DEFI_MATERIAU` [U4.43.01]. Thermal conductivity (keyword `LAMBDA`) is **always taken equalizes to 1**. Specific heat (keyword `RHO_CP`) play the part of **density of the fluid**.

- ◆ LOAD = load

Thermal load of type `[char_ther]` necessary to the resolution of the linear system rising from the equation of Laplace in the fluid. One must impose a temperature **unspecified** (which plays in fact the part of a pressure) on a node **unspecified** fluid grid, in order to make the system nonsingular. This operation is carried out with the operator `AFFE_CHAR_THER` [U4.44.02].

3.4 Operands MODE_MECA / CHAM_NO / MODELE_GENE

- ◆ / MODE_MECA = modes

Dynamic modes calculated on the model structure. If there are several nonrelated structures immersed in the same fluid, for which one wants to determine the added matrices including the terms of coupling by the fluid, the model structure which one defines gathers the totality of the immersed structures. The modes used by the operator are the modes calculated for the total structure.

- / CHAM_NO = chamno

Field with the nodes of displacements affected on groups of nodes defining the fluid interface/structure. By affecting such a field of displacement on (S) the group (S) of nodes of interface thanks to the operator `CREA_CHAMP`, one can for example easily simulate modes of rigid body of the structures. This operand is to be used if one wants to estimate the terms of the added matrices and coupling for a plane geometry **without doing modal calculation as a preliminary** structure in the vacuum, and which one wants to affect these terms in discrete elements (modeling `DIS_T`). The operand `INFORMATION` must imperatively be active to print the calculated terms.

Caution:

*The use of this operand **excludes** that of the operand `NUME_DDL_GENE`. One cannot thus do modal, transitory calculation or harmonic by using the operand `CHAM_NO`.*

Indeed, to do calculation of modes out of water, it is necessary to have a matrix of generalized mass and a matrix of rigidity generalized of the structure. This supposes to have done a modal calculation on the structure in the vacuum (what one wants precisely to avoid).

*This operand is used ultimately only for **to evaluate the matrix of mass, rigidity and damping added**, and to use them to couple structures of type beam by discrete elements of mass, for example.*

/ MODELE_GENE = modgen

Generalized model built by the operator `DEFI_MODELE_GENE` [U4.65.02]. This keyword is to be used when one does a calculation by dynamic under-structuring, and that one wants to calculate the matrix of added mass coupling the whole of under - structures. In this case, the substructures can be in different files of grid, these files being able to be themselves distinct from the fluid file of grid. The substructures which have a repetitivity within the fluid are to be netted only once, but one will take care on the level it fluid grid to net all the interfaces fluid/structure. Moreover, it is necessary to take care that the nodes of fluid interface coincide as well as possible with the nodes of interface of structure, in order to be able to recopy, on the basis of geometrical criterion of proximity, the values of the fields of displacement of structure on the nodes of fluid interface (see operand `DIST_REFE`).

Caution:

| *The use of this operand makes compulsory that of the operand `NUME_DDL_GENE` .*

3.5 Operand OPTION

This keyword specifies the calculation of mass, rigidity or damping added that one wants to make, while using respectively `'MASS_AJOU'`, `'RIGI_AJOU'`, or `'AMOR_AJOU'`. The two last options of calculation require the presence of a potential (thermal) stationary (see operand `POTENTIAL`).

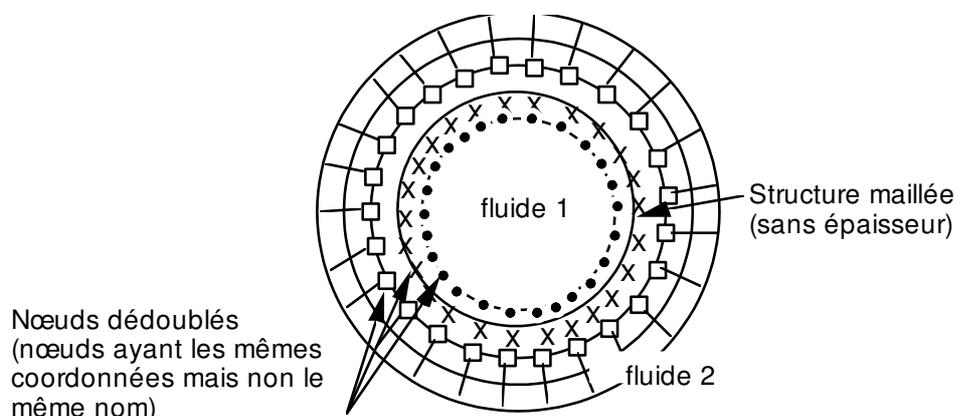
3.6 Operand DIST_REFE

Distance from reference to be informed when one does a calculation of **added mass** on a generalized model. This distance is a geometrical absolute criterion intended to recopy values of structural displacements in a thermal fluid model, in order to solve there the equation of Laplace of the field of non stationary pressure. By default, it is equal to 10^{-2} Mr.

3.7 Operand NOEUD_DOUBLE

◇ `NOEUD_DOUBLE = 'YES'`

This operand is to be used when one does a calculation of **added mass** starting from a generalized model which understands a substructure with a grid by a telegraphic or surface grid (*i.e.* without thickness like beam or hull) and surrounded by two fluids. One needs in this case for the level it grid to duplicate the nodes of the fluid interfaces of those of the structure, in order to be able to calculate the hydrodynamic jump of pressure on both sides of the structure (*cf.* figure Ci - below).



3.8 Operand POTENTIAL

◇ POTENTIAL = phi

Potential (thermal) stationary necessary to the calculation of damping and rigidity added of the structure subjected to a potential flow. This potential is produced by the operator THER_LINEAIRE [U4.54.01].

3.9 Operand NUME_DDL_GENE

◇ NUME_DDL_GENE = numgen

Generalized classification based on the mechanical modes of the total structure. The presence of this operand makes it possible to calculate a matrix of added mass of type `matr_asse_gene_R`. It must be necessarily present if one wants to do modal, harmonic or transitory calculation thereafter.

3.10 Operand INFORMATION

◇ INFORMATION =

Indicate the level of impression of the results of the operator on the file MESSAGE.

- 1: no impression,
- 2: impression of the higher triangular part of the matrices of added mass, added damping or rigidity.

Presentation in column.

3.11 Keyword factor SOLVEUR

See [U4.50.01].

3.12 Operand AVEC_MODE_STAT

The calculation of the terms of mass added on the static modes contained in the modal base of the substructures a calculation with a generalized model makes it possible to in the case of disconnect (*cf.* [§3.4]).

3.13 Operand NUME_MODE_MECA

Allows to specify a list of numbers of modes retained for calculation.

4 Production run

It is checked that the models fluid and interface are quite thermal.

It is checked that the storage of the added matrices is done on a profile **full**.

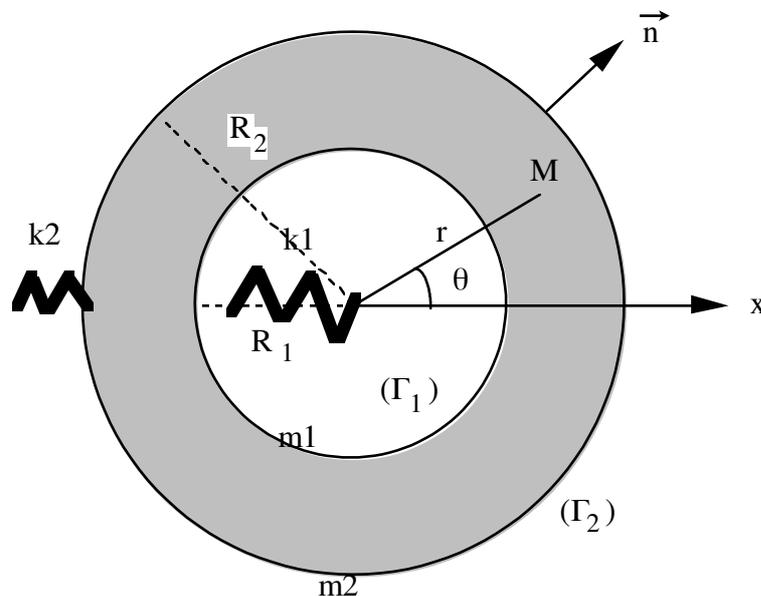
It is checked that the coefficients of added auto-mass (diagonal terms of the matrix) are well all positive. In the contrary case, a message of alarm is transmitted so that the user checks the orientation of the normals.

It is checked that, for a calculation of added damping or rigidity, the keyword `POTENTIAL` is quite well informed.

In the case of a calculation of mass added on a generalized model, one informs the user on the recopies of fields of structural displacements in the fluid (many recopied values) and one indicates how to change the distance from reference (`DIST_REFE`).

5 Example: Calculation of the matrix of mass added of a structure made up of two concentric cylinders separated by an incompressible fluid

The cylinders are supported each one by springs. The matrix of added mass is calculated for the first two modes of the structure, namely the modes of rigid body of each cylinder in direction OX (cf. diagram). One will present here only the stages of the command file, because this example is inspired by CAS-test FDLV101 [V8.01.101]. For the detail of the syntax of the other operators, the user will be able to thus refer to the command file of this CAS-test.



- 1) Definition of fluid material by equivalent thermal characteristics:
- 2) Assignment of this fluid material on the fluid grid including the group of mesh defining the fluid interface/structure.
- 3) Assignment of the fluid thermal model (also including the interface)
- 4) Assignment of the thermal model of interface
- 5) Assignment of the model structure total (including the two cylinders and their springs of self-supporting quality)
- 6) Assignment of a temperature imposed in the fluid grid
- 7) Calculation of the clean modes of the structure in the vacuum
- 8) Generalized classification based on the calculated mechanical modes
- 9) Calculation of the matrix of added mass of type `matr_asse_gene_r` (operand `NUME_DDL_GENE` present). So one can then calculate the clean modes of the "wet" structure

```
matraj = CALC_MATR_AJOU(MODELE_FLUIDE = fluid ,
                        MODELE_INTERFACE = interf ,
                        CHAM_MATER = chammat1,
                        LOAD = load,
                        OPTION = 'MASS_AJOU',
                        MODE_MECA = modes,
                        NUME_DDL_GENE = numgen,
                        INFORMATION =1)
```

- 10) Calculation of the matrices of mass and stiffness generalized on generalized classification based on the calculated mechanical modes `numgen`. These matrices are of type `[matr_asse_gene_r]`
- 11) Calculation of the matrix of total mass of the structure (matrix of generalized mass more matrix of added mass)
- 12) Calculation of the modes of the immersed structure.
- 13) Restitution of the modes "wet" on physical basis.