FDLV104 - Calculation of mass added on model generalized 3D

Summary:

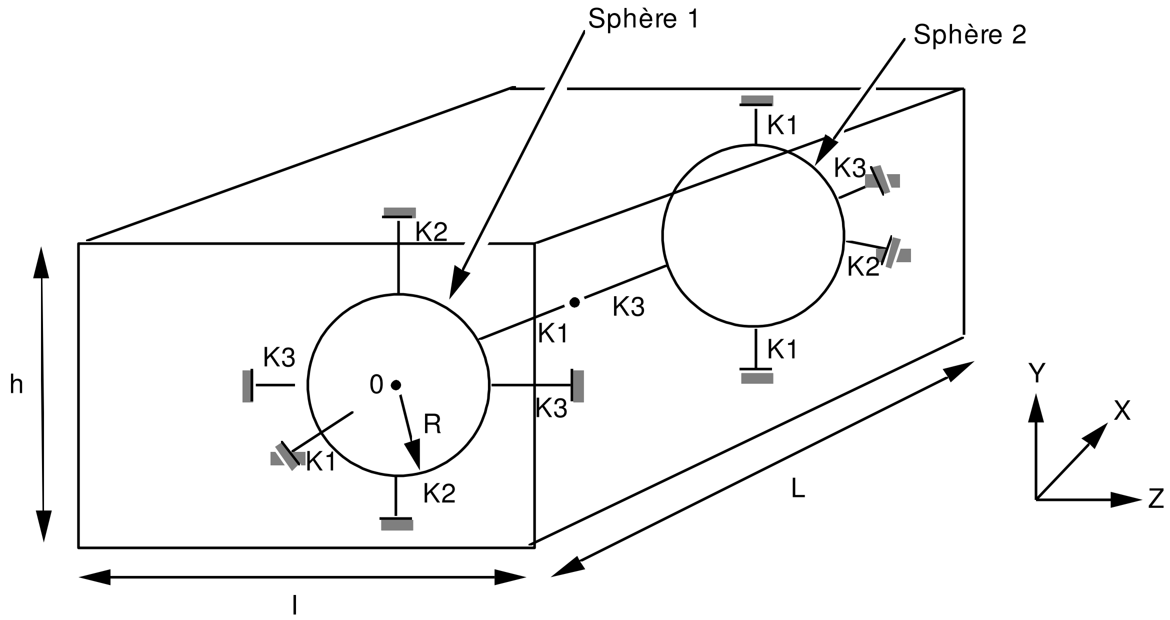
This test of the field of the fluids (fluid coupling/structure) validates the calculation of mass added on a generalized model of type 3D, namely two spheres coupled by an incompressible fluid.

By a modal analysis carried out by dynamic under-structuring, one obtains the coupled modes of the two spheres because of the presence of the fluid. The Eigen frequencies are compared with those determined by a direct calculation.

One obtains the Eigen frequencies with a margin of less than 3%.

1 Problem of reference

1.1 Geometry



Length:	$L=4\,m$
width:	$l=2\,m$
height:	$h=2\,m$
Thickness of the hulls:	$e=10^{-3}\,m$
Ray of the spheres:	$R=0.5\,m$

1.2 Properties of materials

Structure: steel - material elastic

$E=2.10^{11}\,Pa$

$\nu=0.3$

$\rho_s=7800\,kg/m^3$

The springs have as respective stiffnesses:

$K1=10^6\,N/m$ $K2=10^5\,N/m$ $K3=10^7\,N/m$

Fluid: water - thermal material are equivalent

$\lambda=1.$

the specific heat plays the part of density of the fluid: $\rho_f=1000\,kg/m^3$

1.3 Boundary conditions and loadings

Side structure: degrees of freedom of rotation DRX, DRY, DRZ sphere 1 are blocked:

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DRX: 0.0      DRY MARTINI: 0.0    DRZ: 0.0
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Fluid side: one imposes a pressure (i.e temperature) worthless in a node of the fluid grid.

2 Reference solution

2.1 Method of calculating used for the reference solution

One uses a direct modal calculation to obtain the Eigen frequencies modified by the fluid around the spheres.

The two spheres result by a translation from vector from components $(2, 0., 0.)$ and for a rotation of nautical analyses $(90., 0., 90.)$ what makes it possible to plan to build a model generalized on the 1st sphere. One will be able to carry out same modal calculation with fluid coupling/structure by using the dynamic under-structuring. Calculation **direct** with taking into account of added mass leads to the Eigen frequencies of the immersed system following:

$f_1 = 3.1172\,Hz$
$f_2 = 3.1183\,Hz$
$f_3 = 9.2727\,Hz$
$f_4 = 9.8267\,Hz$
$f_5 = 22.4400\,Hz$
$f_6 = 30.3295\,Hz$

2.2 Results of reference

Direct modal calculation by *Code_Aster*.

2.3 Uncertainty on the solution

Uncertainties on the solution are related on the discretization of the fluid interface/structure and to invariance of the grid by rotation of nautical angles $(90°, 0°, 90°)$.

3 Modeling A

3.1 Characteristics of modeling

Modeling understands:

- side structure:

  336 elements of hulls DKT modelling sphere 1,
  6 discrete elements of type K_TR_L (modeling DIS_TR) modelling the six springs connecting sphere 1 to the solid mass,

- fluid side:

  672 THER_FACE3 thermal elements modelling the fluid interface/structure,
  39,445 THER_TETRA4 thermal elements modelling the fluid.

3.2 Characteristics of the grid

Many meshs and types: 672 meshs TRIA3, 39,445 TETRA4, 6 SEG2

3.3 Values tested

Identification	Hz **Reference**
N°1 mode	3.1172
N°2 mode	3.1183
N°3 mode	9.2727
N°4 mode	9.8267
N°5 mode	22.4400
N°6 mode	30.3295

3.4 Remarks

The variation on the two last Eigen frequencies is explained by a not-symmetry of the grid of the fluid interface/structure (thermal) compared to that of the first. **grid** fluid interface/structure (thermal elements) of the second sphere does not result exactly from that from the first by rotation from nautical angles from $90°, 0°, 90°$.

4 Summary of the results

The results got by calculation by dynamic under-structuring show a perfect agreement with direct calculation. Nevertheless, to have this agreement, it should be taken care that the grids of the interfaces fluid/structure (thermal elements) of the substructures which are repeated inside the fluid grid deduce perfectly by rotations of nautical angle defined in DEFI_MODELE_GENE.