SDLS104 - Coaxial shells under Summarized

annular flow

One considers a hardware configuration made up of two coaxial cylindrical shells, in interaction with a fluid running out in annular space separating the shells.

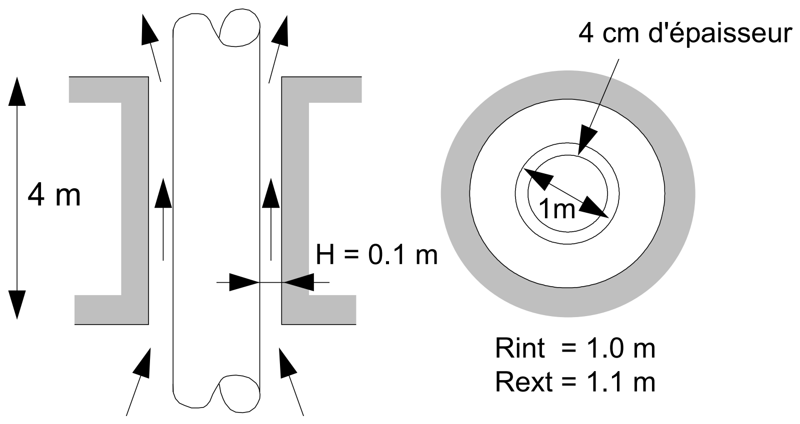
The goal of this benchmark is to validate the model fluid-structure coupling developed in operator `CALC_FLUI_STRU` for this kind of configurations.

One is interested here more particularly in the evolution of the modal parameters (frequency and reduced damping) according to the rate of flow of the fluid. The reference solution is provided by a computation carried out with code MOCCA (Coupling in Annular Containment Models).

1 Problem of reference

1.1 Geometry

the studied configuration consists of two coaxial cylindrical shells $4\,m$ height



the inner shell has an average radius R_1 of $0{,}98\,m$ and a thickness e_1 of $4\,cm$.

The outer shell has an average radius R_2 of $1{,}105\,m$ and a thickness e_2 of $1\,cm$.

Note:

The thickness and the average radius of annular space between the two shells are given by

$$H=R_{\text{ext}}-R_{\text{int}}=0{,}1\,m \qquad R=\frac{R_{\text{int}}+R_{\text{ext}}}{2}=1{,}05\,m$$

with

$$R_{\text{int}}=R1+\frac{e_1}{2}=1\,m \qquad R_{\text{ext}}=R_2-\frac{e_2}{2}=1{,}1\,m$$

1.2 Properties of the material

the material constituting the two shells is steel. Its physical characteristics are

$$\rho=7800\,kg/m^3 \qquad E=2.\,10^{11}\,Pa \qquad \nu=0{,}3$$

1.3 Boundary conditions and loadings

the outer shell is supposed to be rigid: all the nodes are clamped.

Concerning the inner shell, the conditions of self-supporting quality are the following ones: partly lower embedded end ($z=0$) and free partly higher ($z=4\text{m}$).

2 Reference solution

2.1 Method of calculating used for the reference solution

the reference solution is obtained by a computation carried out by means of code MOCCA (Coupling in Annular Containment Models) [bib1], [bib2]. This last was validated on several experimental configurations of which models TAXI of the French atomic energy agency [bib2] and GRAPPE2 from EDF [bib3].

The modal characteristics of structure except flow being informed, code MOCCA makes it possible to calculate the evolutions of the frequencies and reduced dampings of each mode of structure according to the rate of flow. This resolution is carried out numerically by a method of the finite differences type.

The evolutions of the modal parameters associated with the first mode of a nature of shell equal to 1 constitute, in this case, the reference solution.

2.2 Results of reference

One considers the fifth mode of structure, first mode of order 1 in shell. The eigenfrequency of this mode except flow is of $90{,}4\,Hz$.

Mean velocity of flow (m/s)	**Eigenfrequency** (Hz)	**modal Reduced damping** (%)
0.	31,8794	0,0353905
5.	31,8806	1,27602
10.	31,8842	2,50164
15.	31,8900	3,74046
20.	31,8982	4,97402
25.	31,9087	6,20616
30.	31,9217	7,43705
35.	31,9372	8,66394
40.	31,9546	9,89269

2.3 Uncertainty on the solution

The model of fluid-structure coupling MOCCA_COQUE [bib4] reabsorbed in operator `CALC_FLUI_STRU` was developed in structure shells optics. It makes it possible to take into account modes of shells of an unspecified nature but is limited to uniform annular clearances.

Code MOCCA was for its part developed with a view to motions of type beam, under the effect of annular flows of variable thickness. One will thus establish comparisons for modes of a nature of shell equal to 1, in the presence of uniform annular flows.

The model MOCCA_COQUE is purely analytical, while code MOCCA leans on a method of resolution numerical of the fluid problem. Differences between the reference solution and the results of *the Code_Aster* are thus to wait.

2.4 Bibliographical references

1.L. PEROTIN, S. GRANGER, “A numerical model for fluid-structure coupling of has confined cylinder submitted to axial year annular flow”, proceedings fifth international symposium one flow - induced vibration and noise, Anaheim, CA, 1992, vol. 5, pp. 1-16.

2.L. PEROTIN, S. GRANGER, “A linearized unsteady model for computing the dynamics of cylindrical structures subjected to non-uniform annular flows At high international Reynolds numbers”, proceedings sixth conference one flow-induced vibration, London, April 1995 “Newspaper of Fluids and Structures” (1997) 11,183-205.

3.L. PEROTIN, S. GRANGER, “Computational simulation of the hydroelastic behavior of model GRAPPE2, using code MOCCA”, HT-32/93/017/A.

4.L. PEROTIN, “Note of principle of model MOCCA_COQUE”, HT-32/95/021/A.

3 Modelization A

3.1 Characteristic of the modelization

the geometry of structures and the characteristic of the material constituting the shells were presented before.

Concerning the absolute roughness of wall of structures, one takes a value of $10^{-5} m$.

The surrounding fluid is water. The values taken for the density and kinematical viscosity are respectively

$$\rho_f = 1000 kg/m^3 \qquad \nu_f = 10^{-6} m^2/s$$

One considers the flow not confined upstream and downstream from structures.

The model of resolution used is the model analytical MOCCA_COQUE reabsorbed in *the Code_Aster* (operator CALC_FLUI_STRU). One selects the fifth mode in air of structure then one solves for this mode the problem of coupling. The mean velocities of flow vary from 0 with $40 m/s$ by step of $5 m/s$. One thus obtains for this mode the evolutions of the eigenfrequency and reduced damping according to the rate of flow.

3.2 Characteristics of the mesh

the two shells are with a grid in an identical way. In order to make them interdependent one of the other, one adds a mesh group connecting the nodes to the level of the fixed support.

One a: 17 nodes on a vertical generator
60 nodes on a contour

960 meshes QUAD4 on each shell
60 meshes QUAD4 to solidarize the two shells (bases clamped)

3.3 Features tested

Operator DEFI_FLUI_STRU : definition of the characteristics of a hardware configuration made up by two coaxial cylindrical shells for a computation of fluid-structure coupling; factor key word COQUE_COAX.

Operator CALC_FLUI_STRU : resolution of fluid-structure coupling for a configuration of the type “coaxial shells”; computation of the evolutions of the modal parameters (frequencies and reduced dampings) according to the rate of flow of the fluid.

4 Results of the modelization A

4.1 Values tested

Evolutions of the eigenfrequency and the reduced damping of the fifth mode in air of structure, according to the mean velocity of flow.

Rate of flow (m/s)	Frequency MOCCA (Hz)	Frequency *Aster* (Hz)	variation (%)	Amor. reduced MOCCA (%)	Amor. reduced *Aster* (%)	variation (%)
0.	31,8794	32,5315	2,046	0,0353905	0,0359752	1,652
5.	31,8806	32,5327	2,045	1,27602	1,24509	– 2,114
10.	31,8842	32,5361	2,045	2,50164	2,43947	– 2,485
15.	31,8900	32,5419	2,044	3,74046	3,64669	– 2,507
20.	31,8982	32,5500	2,043	4,97402	4,84884	– 2,517
25.	31,9087	32,5603	2,042	6,20616	6,04989	– 2,518
30.	31,9217	32,5731	2,041	7,43705	7,24936	– 2,524
35.	31,9372	32,5880	2,038	8,66394	8,44513	– 2,526
40.	31,9546	32,6054	2,037	9,89269	9,64298	– 2,524

4.2 Remarks

the results are in conformity so that one could wait.

A variation of about 2% on the frequency and reduced damping and the appears, ascribable with the differences between the models methods of resolution. This variation is reasonable taking into account the initial frequency of structure except flow ($90{,}4\,Hz$).