FDLV105 - Added mass on axisymmetric piston coupled to a Summarized incompressible fluid column

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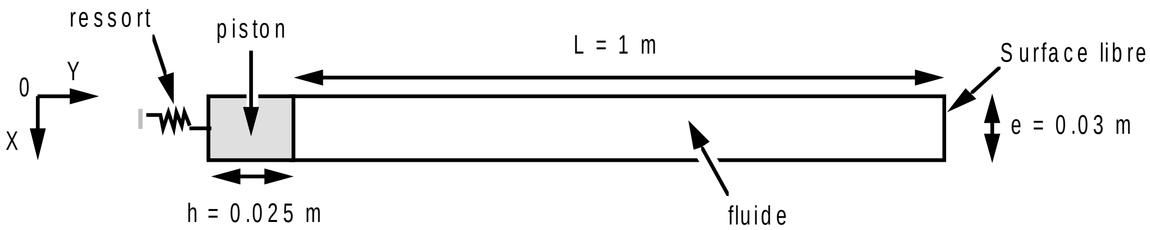
This test of the field of the fluids implements a modal analysis on a system coupled incompressible fluid structure of standard piston column of fluid with free surface. The piston and the fluid are modelled respectively by machine elements and thermal **axisymmetric**. One thus validates the computation of added mass in axisymmetric configuration.

1 Problem of reference

1.1 Geometry



the system consists of a circular piston vibrating in contact with an annular fluid column finished by a free surface:

Length: $1\,m$
width: $0.03\,m$
height: $0.025\,m$

the axis of revolution is the axis OY of the reference. OX indicate the radial axis.

1.2 Properties of the materials

Structure: steel - elastic material

$E=2.10^{13}\,Pa$
$\nu=0.3$
$\rho_s=7800\,kg/m^3$

spring has a stiffness by Fluid radian $K=\frac{10^5}{2\pi}\,N/m/rad$

: thermal material are equivalent

$\lambda=1.$
$\rho_f C_p=1000.$

1.3 Boundary conditions and loadings

Side structure: the degree of freedom DX of all the nodes of structure is blocked: `DX: 0.0`

fluid Side: one null imposes a pressure (i.e temperature) on the nodes of free surface. Reference solution

2 Method of calculating

2.1 used for the reference solution One

solves the analytically following coupled problem: with

$$\begin{cases} m\ddot{y}+k\,y=F \\ \dfrac{\partial^2 p}{\partial y^2}=0 \\ \left(\dfrac{\partial p}{\partial y}\right)=\rho_f\,\ddot{y} \end{cases}$$

hydrodynamic

F compressive force on the hydrodynamic piston

P pressure in the fluid:

m, k mass and stiffness of the piston by radian

the hydrodynamic field of pressure in the fluid is written: from where

$$p=-\rho_f\,\ddot{y}(y-l)$$

the compressive force being exerted on the piston:

$$F=\int_0^e p\,\mathbf{n}\,r\,dr=-\rho_f\,\ddot{y}\,l\,\frac{e^2}{2}$$

the added mass by radian is worth: $m_a=\rho_f\,l\,\frac{e^2}{2}$

the eigen mode of the coupled system is worth: Results $f=\frac{1}{2\pi}\sqrt{\frac{k}{m+m_a}}=27{,}25\,Hz$

2.2 of Analytical reference

. References

2.3 bibliographical GIBERT

1.R.J.: Vibrations of structures, Eyrolles (1988). Modelization

3 A Characteristic

3.1 of the modelization Side

- structure: 8

  machine elements axisymmetric MEAXQU 4,1

  point element of the type K_T_N modelling spring, fluid

- side: 380

  thermal elements axisymmetric THAXQU 4 modelling the fluid, 8

  thermal elements axisymmetric THAXSE 2 modelling the fluid interface/structure. Characteristics

3.2 of the mesh Side

structure: 8	meshes QUAD4 fluid 1maille POI1	Side: 8	meshes SEG2 320 meshes QUAD4 Number of meshes
: 337	Values		

3.3 tested Identification

Reference	Hz **Mode**
n°1 27.25	Summary

4 of the results The computation

of added mass on axisymmetric elements is very well carried out. It will be noted however that the calculated quantities are added masses by radian (divided by). 2π