SDLS139 - Identification of fluid forces on a telegraphic structure

Abstract:

This benchmark is used as validation with the macro-command CALC_ESSAI, which is an interactive operator of identification of forces on telegraphic structure. Several methods are proposed, and are by the operator tested here:

[1] expansion of experimental data on a digital model,

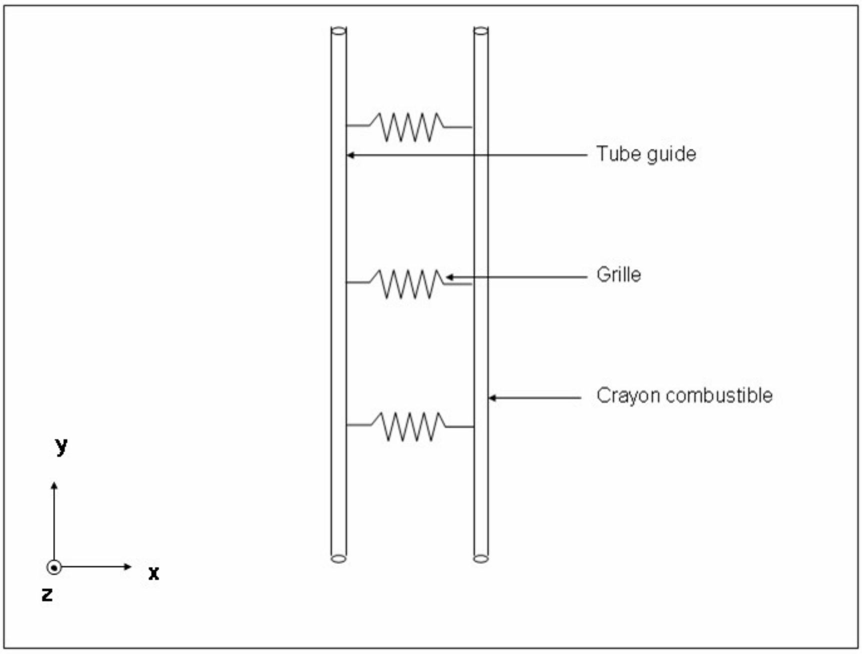
[2] identification of turbulent forces by decomposition on modal base,

the benchmark simulates the data necessary to the use of macro:
•a mesh of fuel pin, stiffened by a tube guides,
•a modal base associated with this structure,
•simulation of forces fluid-elastics, at rest, and out of flow,
•simulation of an inter-spectrum of forces turbulent, according to a model of CORCOS,
•simulation of displacements of the pencil induced by this force, restitution on 19 “sensors”,
•creation of models of observability (mesh with 19 sensors) and of command (mesh with 3 nodes).

Then, the macro-command uses these data as starter to identify the simulated forces (turbulent forces fluid-elastics and forces).
The macro one is normally used in mode INTERACTIF. When it is not the case, as in this case, the execution of the command is done in the source code of this one, which carries out, instead of the user, the functions of identification.

1 Problem of reference

1.1 Geometry



the geometry is a fuel pin height $4{,}5\,m$, thickness $0{,}5\,mm$ and diameter $0{,}9\,cm$, regularly attached, via the grids of maintenance, with a tube guides, more rigid, of thickness $0{,}5\,mm$ and diameter $1{,}245\,cm$.

1.2 Properties of the material

the material is homogeneous, isotropic, elastic linear. The elastic coefficients are:

1) $E=98\,400\,MPa$ $\nu=0.3$, and $\rho=6526\,kg.m^{-3}$ for the guide
2) $E=98\,400\,MPa$ $\nu=0.3$, and $\rho=6526\,kg.m^{-3}$ for the pencil.

1.3 Mechanical modelization

the grids are of the elements of stiffness of the type `DIS_TR`, the pencils are elements `POU_D_T` of Timoshenko.

1.4 Boundary conditions and loadings

the pencil is embedded at its ends, and only displacements according to DX are authorized.

2 Simulation of the data

2.1 Bases in air

modal base, known as "in air", is simulated with MODE_ITER_SIMULT. The modes are then standardized compared to the mass. One recovers this simulation *a sd_resultat mode_meca* called MODEAIR.

2.2 Turbulent forces

the force is applied to two nodes, according to an inter-spectrum with two components. Each spectrum applied has the form of gaussian. The two excitations are uncorrelated (the inter-spectrum $(1,2)$ is a function null).
Operator DYNA_ALEA_MODAL calculates modal displacements from this force for base MODEAIR, and REST_SPEC_PHYS restores these displacements on physical base, on 19 points only, which simulate experimental measurement. This result is called SPECTR19.

2.3 Models of forces and commandability

the user must define the experimental mesh used during the experiment, as well as the positions of the specific points on which it wishes to project the identified forces (commandability), with the associated degrees of freedom:

1) translation if one wishes to identify only specific forces,
2) translation and rotation if one wishes to identify specific forces and moments.

3 Launching of CALC_ESSAI

the command used for the launching of macro is the following one:

```
CALC_ESSAI (INTERACTIF = "NON",
      EXPANSION = _F (CALCUL = MODEAIR,
                      NUME_MODE_CALCUL = (1,2,3,4,5,6,7,8,),
                      MESURE = MODCRA,
                      NUME_MODE_MESURE = (1,2,3,4,5,6,7,8,)),
      IDENTIFICATION   = _F (ALPHA = 0.0, EPS = 0.0,
                             INTE_SPEC = SPECTR19,
                             OBSERVABILITY  = OBS,
                             COMMANDABILITE = COM,
                             BASE = MODEAIR),
      RESU_IDENTIFICATION = (_F (ARRAY = CO ("FORCES")),
                              _F (ARRAY = CO ("DEPL_PHY")),
                              _F (ARRAY = CO ("DEPL_SYN")),),
          );
```

3.1 Meaning of the key words

3.1.1 Modulates "EXPANSION "

modulus "EXPANSION " makes it possible to launch the macro MACRO_EXPANS, which carries out the modal expansion of experimental data on a digital model. It uses operators EXTR_MODE, PROJ_MESU_MODAL, REST_GENE_PHYS and PROJ_CHAMP.
In these benchmark, one extends modes 1,2,3,4,5 and 6 of MODCRA by means of as bases expansion modes 1,3,4,5,6,7 of base MODEAIR.

One creates in continuation the new concepts aster RESU_NX, RESU_EX, RESU_ET and RESU_RD in the macro-command. In interactive, the naming can be done in an interactive way.

Lastly, one prepares the MACS between modes the concepts created (operator MAC_MODE) and the visualization of the deformed shapes with gmsh (operator IMPR_RESU, FORMAT=' GMSH').

3.1.2 Modulate "FLUDELA "

the modulus fludela was removed in version 9 of Code_Aster. It was about a functionality making it possible to identify the coefficients of mass, stiffness and damping added by comparison between them of modal bases of structures identified in air, water and flow.
NB: at the end of the command file, one shows how to simulate the setting in water and under flow of the base of calculated mode, with operators DEFI_FLUI_STRU and CALC_FLUI_STRU (axial flow assumption).

3.1.3 Modulate "IDENTIFICATION "

the principle of mitre "IDENTIFICATION " is an inter-spectrum to identify forces from the data of the inter-spectrum of displacements measured on a structure.

- inter-spectrum: key word INTE_SPEC, one takes SPEC19,
- modal base: key word BASE, one takes RESU_ET, obtained in the mitre "correlation",
- mesh of observability: key word MODELE_MESURE, one takes MODPROJ1,
- mesh of commandability: key word MODELE_COMMANDE, one takes MODPROJ2,
- parameters of regularization: they are null in the frame of this benchmark, but have authority to be adjusted when one uses data of real measurements (disturbed).

In noninteractive mode, the output of the modulus of identification is by default:

- the inter-spectrum of the identified forces (called "FORCES "),
- the inter-spectrum of displacements as starter (called "DEPL_PHY "),
- the inter-spectrum of Re-synthesized displacements (called "DEPL_SYNTH ", to compare with the precedent).

The inter-spectrums are data structures sd_table_fonction. Caution: this data structure is reserved for the inter-spectrums of small, ideally for measured data (about a few tens of points of measurement max). They are not adapted to the numerical data of big size. The inter-spectral matrixes are indeed square matrixes full with size nb_{ddl}^2.

4 Checking of the quality of the results

One checks the quality of the identification carried out by calculating value RMS of the difference between displacements measured and the Re-synthesized displacements.
The value of reference to be reached is zero, with an accuracy of 10^{-3} , to compare with the value of the RMS of measured displacement (about 10^{1}).

This checking can be realized in the real case where one does not know the forces applied (since one wishes to identify them), and that the only quality standard of result of inverse problems, is the capacity of the forces to find measured displacements. But it should not be forgotten that several different inputs can lead to the same measured displacement. The choice of the localization a priori of the forces is important. It is pointed out that so that the inverse problems are on-given, it is necessary to respect the double-inequality $nb_{mes}>nb_{modes}>nb_{act}$, ouformule nb_{mes} is the number of points of measurement, nb_{modes} is the number of modes used in modal decomposition, and nb_{act} is the number of points of localization of the forces chosen a priori.
If one seeks to identify a fluid force applied to a linear structure, one is in general satisfied to identify an “equivalent” force applied to a point of structure.