SDLL148 – definition of an analytical inter-spectrum of excitation on a beam and projection on modal basis

Summary:

This case test makes it possible to validate the option SPEC_CORR_CONV_3 of the operator DEFI_SPEC_TURB, which makes it possible to define a spectrum defined by a set of analytical functions, and to project this one on a basis of modes.

1 Problem of reference

1.1 Geometry of the digital model

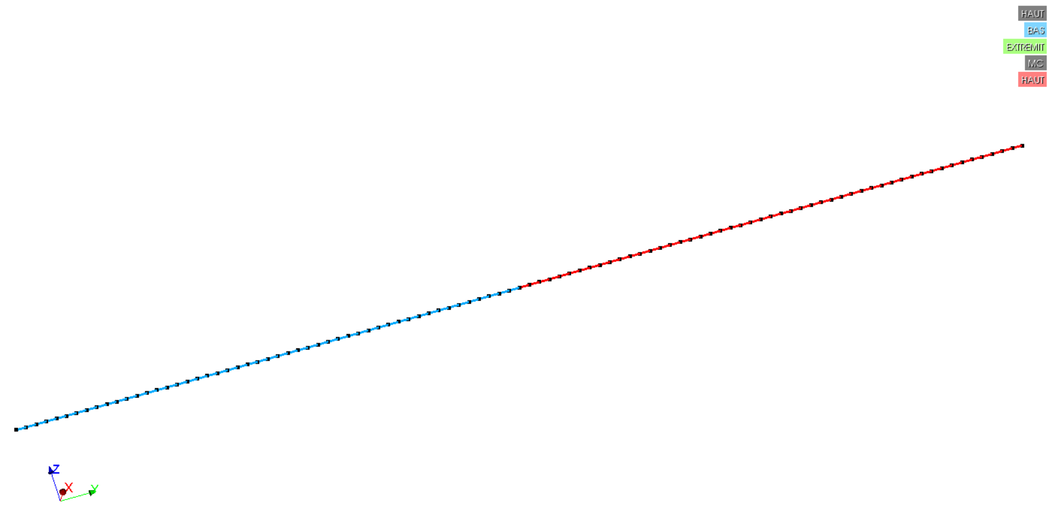

Illustration 1.1: grid of the model.

1.2 Groups of meshs and nodes

- groups of nodes and meshs MC : all the beam,
- groups of nodes and meshs BAS : low half (in blue),
- groups of nodes and meshs $HAUT$: high half (in red),
- group of node $EXTREMIT$: base beam.

1.3 Properties of materials

- For all the elements
  - $E=2.2\times10^{11} Pa$ Young modulus
  - $\nu=0.3$ Poisson's ratio
  - $\rho=8333.0 kg.m^{-3}$ Density

1.4 Boundary conditions and loadings

- Imposed displacement:
  - group $EXTREMIT$: $DRX=DRY=DRZ=DX=DY=DZ=0.0$
  - group MC : $DZ=0.0$

1.5 Geometrical characteristics of the elements of structure

- Group MC : section of the type tubes (‘CIRCLE‘):
  - ray: $R=7.94 mm$,
  - thickness: $e=3.176 mm$

2 Objective of the CAS-test, validation

The objective of the CAS-test is to validate the functionality SPEC_CORR_CONV_3 of the operator DEFI_SPEC_TURB , which makes it possible to define a spectrum by using analytical functions of the variable of space and frequency.

In modeling A, the definite spectrum is purely theoretical, since the functions are sines. The calculation of the double integral $\int_{\Omega}\int_{\Omega}\Phi_i(\underline{x_1}).S_f(\underline{x_1},\underline{x_2},\omega).\Phi_j(\underline{x_2})d\Omega_1 d\Omega_2$ can thus be solved in an analytical way, by supposing that the first 2 clean modes of the beam are also functions sine. In modeling B, the definite spectrum is representative of a flow downstream from a grid of mixture on a fuel pin (model of Corcos).

2.1 Course of the CAS-test

- Calculation of the clean modes: the first two clean modes are calculated, they are form $\phi(y)=\sin(\pi y)$ and $\phi(y)=\sin(2\pi y)$,
- definition of the functions of the turbulent spectrum:
  - modeling A $S_{xx}=f.\sin(\pi y_1).\sin(\pi y_2)$
  - modeling B

$$S_f(\underline{x_1},\underline{x_2},\omega)=\begin{cases} S_{xx}=\exp\left(-\frac{|y_2-y_1|}{\lambda_{cx}(\omega)}\right).\exp\left(j\omega\frac{y_2-y_1}{U_c}\right)S_f(y_1,y_1,\omega) \\ S_{yy}=\exp\left(-\frac{|y_2-y_1|}{\lambda_{cy}(\omega)}\right).\exp\left(j\omega\frac{y_2-y_1}{U_c}\right)S_f(y_1,y_1,\omega)\end{cases}$$

  (while adding terms of correlation enters the efforts according to x and y with the functions S_{xy} and S_{yx}).
- creation of a table containing the functions associated with the directions,
- creation of the inter-spectrum with DEFI_SPEC_TURB,
- projection of the inter-spectrum on the two clean modes calculated with PROJ_SPEC_BASE ; projection is done on the group of meshs 'LOW' only.

Note:

For modeling B, one defines an excitation in the two directions. However, the two calculated modes are in the direction X (direction DZ is blocked). Thus the excitation according to Y no influence on the result of the modal excitation will have.

2.2 Validation of the results

2.2.1 Modeling A

For modeling A, the validation is analytical. Indeed, the integrals to be calculated are the following ones:

- auto--spectrum mode 1: $\int_0^{0.5}\int_0^{0.5}\sin^2(\pi y_1)\sin^2(\pi y_2)\,dy_1 dy_2=\frac{1}{4}.\frac{1}{4}=0.0625$
- inter-spectrum mode 1 – mode 2:

$$\int_0^{0.5}\int_0^{0.5}-\sin^2(\pi y_1)\sin(\pi y_2)\sin(2\pi y_2)\,dy_1 dy_2=-\frac{2}{3\pi}.\frac{1}{4}=-0.05305$$

- auto--spectrum mode 2:
$$\int_0^{0.5}\int_0^{0.5}\sin(\pi y_1)\sin(2\pi y_1)\sin(\pi y_2)\sin(2\pi y_2)dy_1 dy_2 = -\frac{2}{3\pi}.-\frac{2}{3\pi} = 0.04503$$

2.2.2 Modeling B

For modeling B, the validation is done by nonregression.

- auto--spectrum mode 1: 0.11
- inter-spectrum mode 1 – mode 2: $0.11+0.01534j$
- auto--spectrum mode 2: 0.11 .