SDLL140 – Computation of the eigen modes of a beam with 3 discs, subjected to the gyroscopic effect.

Abstract:

This problem consists in validating the effect of the gyroscopic matrix on a beam supported on each one of its ends, on linear bearings. The beam is full, of circular section and comprises three discs.

Two computations are carried out:

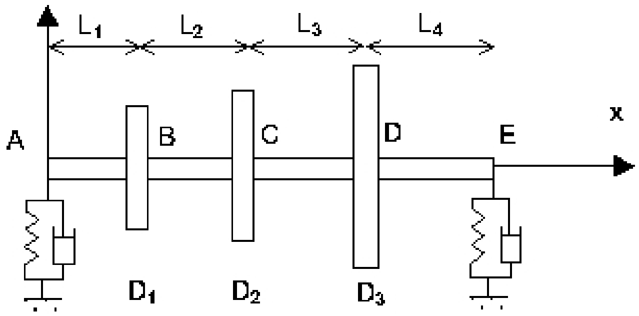
- Computation a: rotational speed null, no gyroscopic effect, computation of the eigenfrequencies,
- Computation b: non-zero rotational speed, gyroscopic presence of effect, computation of the eigenfrequencies,

This problem thus makes it possible to test the effect of the gyroscopic matrix which was developed for a straight beam. The gyroscopic effect led to the unfolding of the modes. The evolution of the eigenfrequencies according to rotational speed makes it possible to build the diagram of Campbell.

The got results are in concord with those given in reference. The references are based on the theory of the beams of Timoshenko.

1 Problem of reference

1.1 Geometry



Modelization:

	Mass (kg)	I_{xx} ($kg.m^2$)	$I_{yy}=I_{zz}$ ($kg.m^2$)
Disc D_1	14.580130	0.1232021	0.6463858
Disc D_2	45.945793	0.97634809	0.4977460
Disc D_3	55.134951	1.176177	0.6023493

Table 1.1-1 : Characteristics of the discs

Length of beam:

$L_1=AB=0.2\,m$
$L_2=BC=0.3\,m$
$L_3=CD=0.5\,m$
$L_4=DE=0.3\,m$

Circular section:

Diameter: $D=0.1\,m$

1.2 Elastic

$E=2.10^{11}\,Pa$
$\nu=0.3$
$\rho=7\,800\,kg/m^3$

1.3 material properties Boundary conditions and

loadings Bearings with viscous damping in A and in E

$K_{yy}=5.10^7\,N.m^{-1}$; $K_{zz}=7.10^7\,N.m^{-1}$; $K_{yz}=K_{zy}=0$
$C_{yy}=5.10^2\,N/(m.s^{-1})$; $C_{zz}=7.10^2\,N/(m.s^{-1})$; $C_{yz}=C_{zy}=0$

2 Reference solution

2.1 Method of calculating used for the reference solution

the reference solution is that presented in the work of Michel LALANNE and Guy FERRARIS.

The numerical results were got by a code finite elements, with elements beam of the Timoshenko type. The modelization is realized with 14 nodes (13 elements beams).

2.2 Results of reference

- the first 10 eigenfrequencies to the stop ($\Omega=0$).
- the first 10 eigenfrequencies at a rotational speed of $\Omega=25000\,tr/min$.
- With a loading of type unbalance, values of the 7 maximas of amplitude for the points A , C and E , for a rotational speed varying from 0 with $30000\,tr/min$.

2.3 Uncertainty on the solution

Lower than 1%.

2.4 Bibliographical references

Michel LALANNE and Guy FERRARIS, Rotordynamics, Prediction in Engineering, JOHN WILEY AND SOUNDS (1990).

3 Modelization A

3.1 Characteristic of the modelization

Modelization : 130 Elements équi-distribute beam POU_D_T in the direction x .

3.2 Characteristics of the mesh

Mesh: Many nodes: 131
Number of meshes and types: 130 SEG2

3.3 Functionalities tested

Commands

CALC_MATR_ELEM	OPTION	"MECA_GYRO"
MODE_ITER_SIMULT		

4 Results

4.1 Computation a: eigenfrequencies, rotor with the stop ($\Omega=0$)

Frequency of reference (Hz)	Frequency Aster (Hz)	% Difference
60.618	60.60643	1.91E-02
63.029	63.01608	2.05E-02
169.513	169.4401	4.3E-02
185.584	185.4870	5.23E-02
329.613	329.4818	3.98E-02
362.089	361.9114	4.91E-02
529.291	529.8633	8.08E-02
557.549	557.0589	8.79E-02
831.111	830.4900	7.47E-02
846.013	845.3138	8.26E-02

Table 4.1-1 : Computation of the eigenfrequencies to the stop

4.2 Computation b: eigenfrequencies, rotor in rotation ($\Omega=25000\,tr/min$)

Frequency of reference (Hz)	Frequency Aster (Hz)	% Difference
55.408	55.4052	5.09E-03
67.209	67.1844	3.66E-02
157.904	157.8519	3.3E-02
193.706	193.5477	8.17E-02
249.898	249.7995	3.94E-02
407.619	407.1379	11.8E-02
446.622	446.2338	8.69E-02
622.654	622.0188	10.2E-02
715.03	713.9362	15.2E-02

Table 4.2-1 : Computation of the eigenfrequencies to the stop (algorithm QZ)

Frequency of reference (Hz)	Frequency Aster (Hz)	% Difference
55.408	55.4052	5.08E-03
67.209	67.1844	3.66E-02
157.904	157.8519	3.3E-02
193.706	193.5476	8.17E-02
249.898	249.7995	3.94E-02
407.619	407.1379	11.8E-02
446.622	446.2337	8.69E-02
622.654	622.0188	10.2E-02
715.03	713.9362	15.2E-02

Table 4.2-2 : Computation of the eigenfrequencies to $25000\,tr/min$ (algorithm of Sorensen)

Frequency of reference (Hz)	Frequency Aster (Hz)	% Difference
55.408	55.4075	8.39E-04
67.209	67.1872	3.25E-02
157.904	157.8626	2.62E-02
193.706	193.5564	7.73E-02
249.898	249.8516	1.86E-02
407.619	407.3783	5.9E-02
446.62	446.5080	2.55E-02
622.65	622.5052	2.39E-02
715.03	714.2990	10.2E-02

Table 4.2-3 : Computation of the eigenfrequencies with $25000\,tr/min$ (resolution in two stages)

5 Summary of the results

One notes that computations of *Code_Aster* reproduce those of the reference accurately. One notes a good establishment of the gyroscopic effect for the beam element, in the case of modal computation.