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

Summary:

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

Two calculations are carried out:

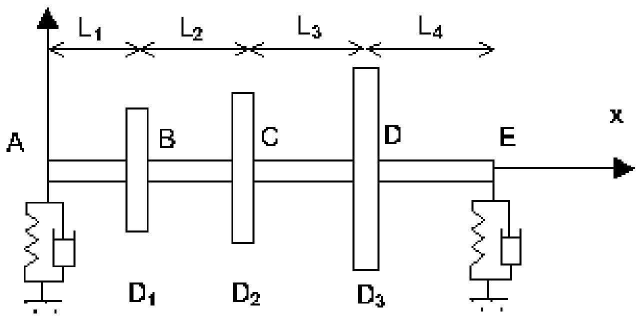
- Calculation a: number of worthless revolutions, no gyroscopic effect, calculation of the Eigen frequencies,
- Calculation b: number of nonworthless revolutions, gyroscopic presence of effect, calculation of the Eigen frequencies,

This problem thus makes it possible to test the effect of the gyroscopic matrix which was developed for a right beam. The gyroscopic effect led to the unfolding of the modes. The evolution of the Eigen frequencies according to the number of revolutions 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



Modeling:

	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	1.1716177	0.6023493

Table 1.1-1 : Characteristics of the discs

Length of the 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 Material properties

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

1.3 Boundary conditions and loadings

Elastic supports 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 digital results were got by a code finite elements, with elements beam of the Timoshenko type. Modeling is carried out with 14 nodes (13 elements beams).

2.2 Results of reference

- the first 10 Eigen frequencies with the stop ($\Omega=0$).
- the first 10 Eigen frequencies at a number of revolutions 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 number of revolutions 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 Modeling A

3.1 Characteristics of modeling

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

3.2 Characteristics of the grid

Grid: Many nodes: 131
Many meshs and types: 130 SEG2

3.3 Features tested

Orders		
CALC_MATR_ELEM	OPTION	'MECA_GYRO'
CALC_MODES		

4 Results

4.1 Calculation a: Eigen frequencies, 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 : Calculation of the Eigen frequencies to the stop

4.2 Calculation b: Eigen frequencies, 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 : Calculation of the Eigen frequencies 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 : Calculation of the Eigen frequencies with $25000\,tr/min$ (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 : Calculation of the Eigen frequencies with $25000\,tr/min$ (resolution in two stages)

5 Summary of the results

It is noted that calculations of *Code_Aster* reproduce those of the reference accurately. One notes a good establishment of the gyroscopic effect for the element of beam, in the case of modal calculation.