SDLL144 – Transient velocity of a beam in rotation with a Summarized

disc:

This test makes it possible to validate the temporal response with a transient rotational speed of a system of rotating shafts. The rotor is full, of circular section and comprises a disc. The models of rise velocity considered here are of type linear (modelization A) and exponential (modelization B).

For this case test, the loading of the standard unbalance is installed on the disc. The comparison relates to the value of the peaks of resonance of displacements of the disc.

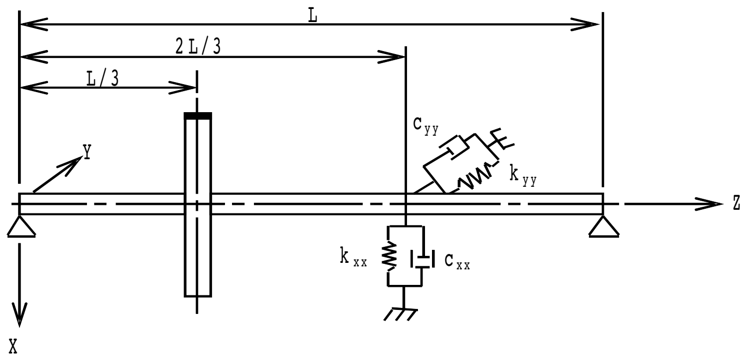
This problem also makes it possible to validate the effect of the damping matrixes and gyroscopic stiffness which were developed for the straight beams of Timoshenko and Euler.

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

the structure is made up of a rotor full with length L with constant circular section with a disc located at the third its length.



Modelization:

	Mass (kg)	I_{zz} ($kg.m^2$)	$I_{xx}=I_{yy}$ ($kg.m^2$)
Disc	16.47	0.1861	0.09427

Table 1.1-1 : Characteristics of the discs

Length of beam:
$L=0.4\,m$

circular Section:
Diameter: $D=0.02\,m$

1.2 Properties of the material

$E=2.10^{11}\,Pa$
$\nu=0.3$
$\rho=7800\,kg/m^3$

1.3 Boundary conditions

the rotor is leaned on two infinitely rigid bearings at the two ends and on an elastic bearing with viscous damping to two thirds its length. The coefficients of the bearing are the following:

$$K_{xx}=2.10^5\,N.m^{-1}\;;\;K_{yy}=5.10^5\,N.m^{-1}\;;\;K_{xy}=K_{yx}=0$$
$$C_{xx}=4.10^1\,N/(m.s^{-1})\;;\;C_{yy}=1.10^2\,N/(m.s^{-1})\;;\;C_{xy}=C_{yx}=0$$

2 Reference solution

2.1 Method of calculating used for the reference solution

the reference solutions that are presented in the work of Michel LALANNE and Guy FERRARIS and that obtained with code CADYRO, software finite elements intended to envisage the dynamic behavior of rotors.

Numerical results CADYRO were got with elements beam of the Timoshenko type. The modelization is realized with 4 nodes (3 elements beams).

2.2 Quantities and results of reference

With a loading of type unbalance, the values tested are the maximas of amplitude for the node corresponding to the disc, and this for two models of rise out of rotational speed going of 0 with $5000\,tr/min$ (notion of resonance at the critical velocity).

2.3 Uncertainty on the solution

Lower than 5%.

2.4 Bibliographical references

•Michel LALANNE and Guy FERRARIS, Rotordynamics, Prediction in Engineering, JOHN WILEY AND SOUNDS (1990).
•CADYRO, software finite elements intended to envisage the dynamic behavior of rotors in bending.

3 Modelization A

3.1 Characteristic of the modelization and the mesh

the rotor is with a grid in 3 finite elements of shaft of the type POU_D_T regularly distributed and comprises 1 discrete element of the type DIS_TR for the modelization of the bearing.

Many nodes: 4
Number and type of elements: 3 SEG2
1 POI1

3.2 Loading

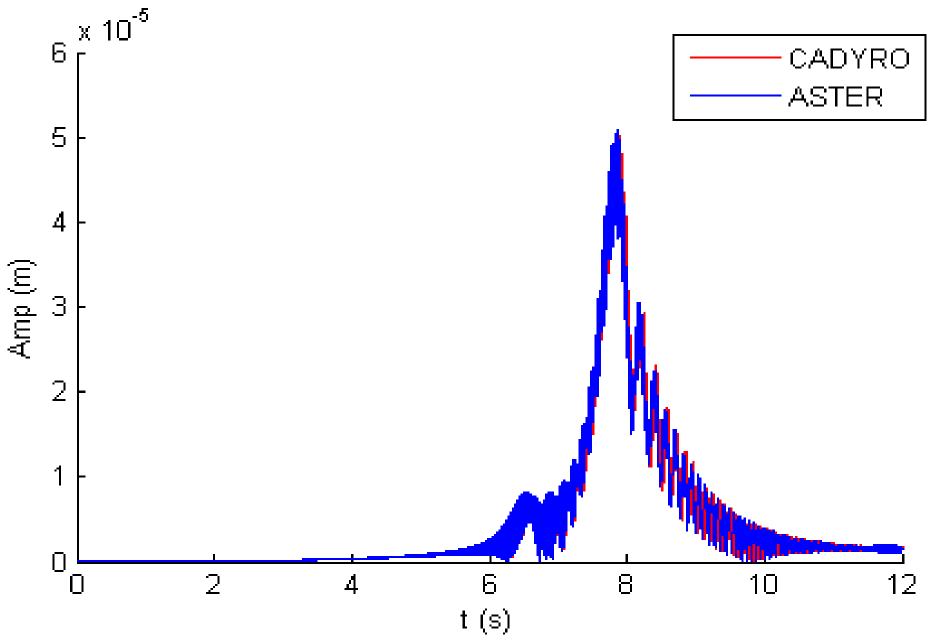
the unbalance are installed on the node disc. It is characterized by a mass of $10^{-4}\,kg$, a distance to neutral fiber of the shaft of $0.15\,m$ and an initial phase shift no one. Its value is of $15.10^{-6}\,m.kg$.
The linear model of rise imposed velocity is the following one: $\dot{\phi}=416,7\,t$

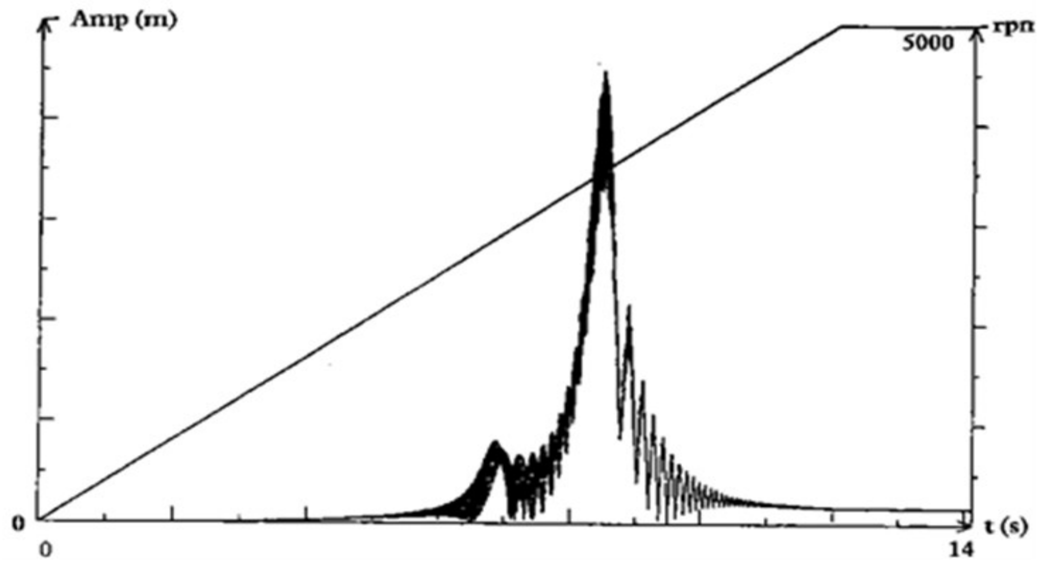
3.3 Results

One tests the time for which vibratory eccentricity reaches its maximum as well as the corresponding maximum amplitude.

Result	A^2_{max} (m)	t_{max} (s)
Reference CADYRO	2.5810E-009	7.89
Reference LALANNE	2.1996E-009	8.44
Code_Aster	2.65697E-009	7.872350
relative Error Aster/CADYRO	3.0%	0.22%
relative Error Aster/LALANNE	20.79%	6.72%

Table 3.3-1 : Quantities tested for a linear model of rise of velocity




Amp (m)
rpn
5000
0
0
t (s)
14

4 Modelization B

4.1 Characteristic of the modelization and mesh

the rotor is with a grid in 3 finite elements of shaft of the type `POU_D_T` regularly distributed and comprises 1 discrete element of the type `DIS_TR` for the modelization of the bearing.

Many nodes: 4
Number and type of elements: 3 SEG2
1 POI1

4.2 Loading

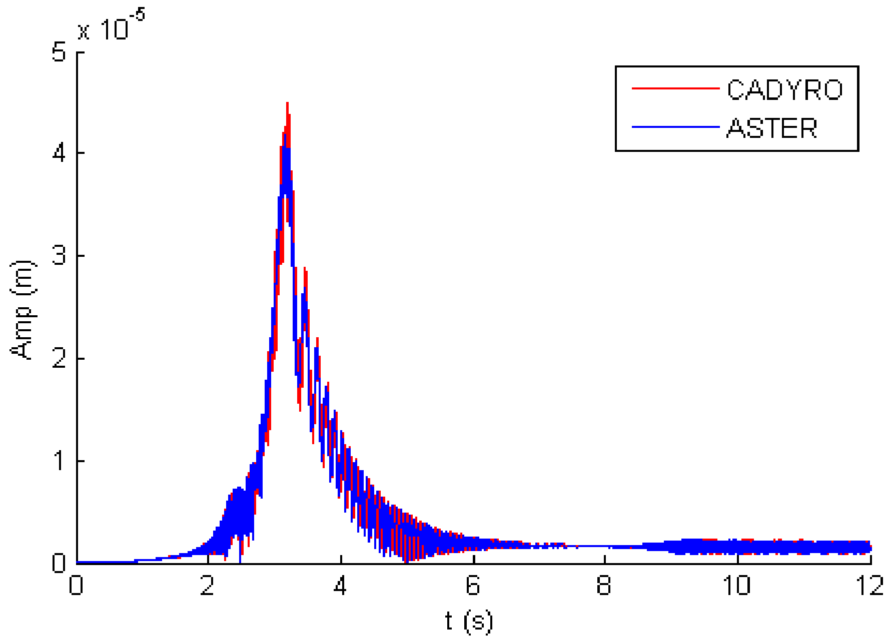
the unbalance are installed on the node disc. It is characterized by a mass of $10^{-4}\,kg$, a distance to neutral fiber of the shaft of $0.15\,m$ and an initial phase shift no one. Its value is of $15.10^{-6}\,m.kg$.
The exponential model of rise imposed velocity is the following one:
$\dot{\phi}=5100\left(1-\exp^{-0.3273t}\right)$

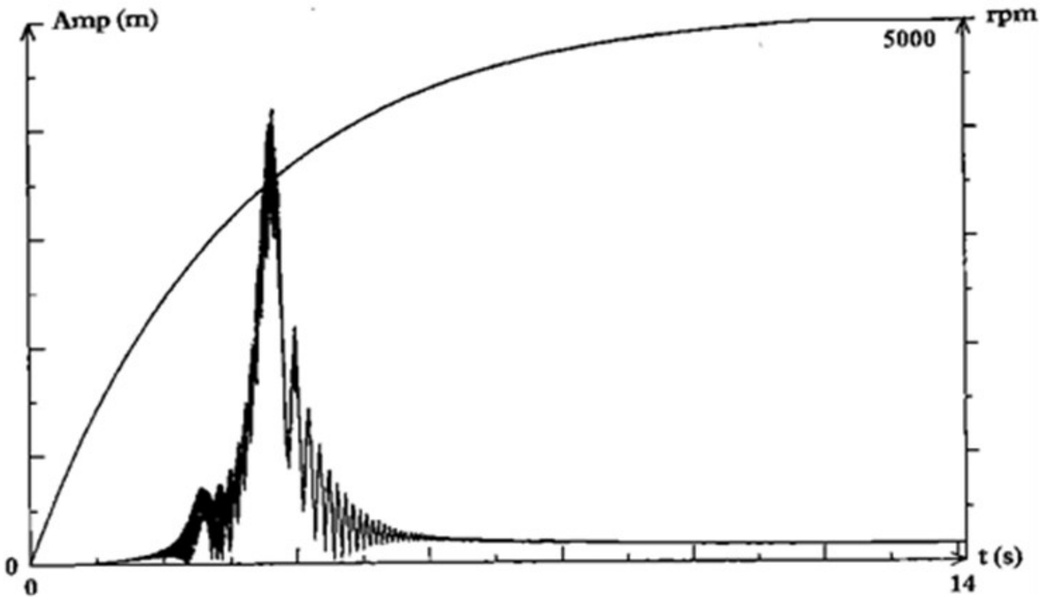
4.3 Results

One tests the time for which vibratory eccentricity reaches its maximum as well as the corresponding maximum amplitude.

Result	A^2_{max} (m)	t_{max} (s)
Reference CADYRO	2.0160E-009	3.19
Reference LALANNE	1.8063E-009	3.5
Code_Aster	2.02639E-009	3.196750
relative Error Aster/CADYRO	0.5%	0.21%
relative Error Aster/LALANNE	12.2%	8.66%

Table 4.3-1 : Quantities tested for an exponential model of rise of velocity





5 Summary of the results

One obtains a good correspondence between the results simulated with CADYRO and Code_Aster (relative errors lower than 3%). However, from the important variations (of 20% at the most) are obtained with the results resulting from the bibliography. These variations can be simply explained by the difference of projection base. Indeed, the space station used in the bibliography takes into account only the first eigen mode of a beam in bending on simple bearings. Code_Aster and CADYRO use a more precise modal base. The method of resolution by modal recombination on an incomplete basis is very sensitive to the truncation effects which tend to rigidify structure overall. This results thus in to increase the resonance frequencies, which explains why the peaks appear for higher rotational speeds and thus later in time (gone up of velocity here). One thus notes a good stiffness and gyroscopic damping matrix installation of for the beam element , in the case of computation of the temporal response on modal base for a transient of rise of velocity .