SDLL128 - Line of trees with plateau characteristics depending on the number of revolutions

Summary:

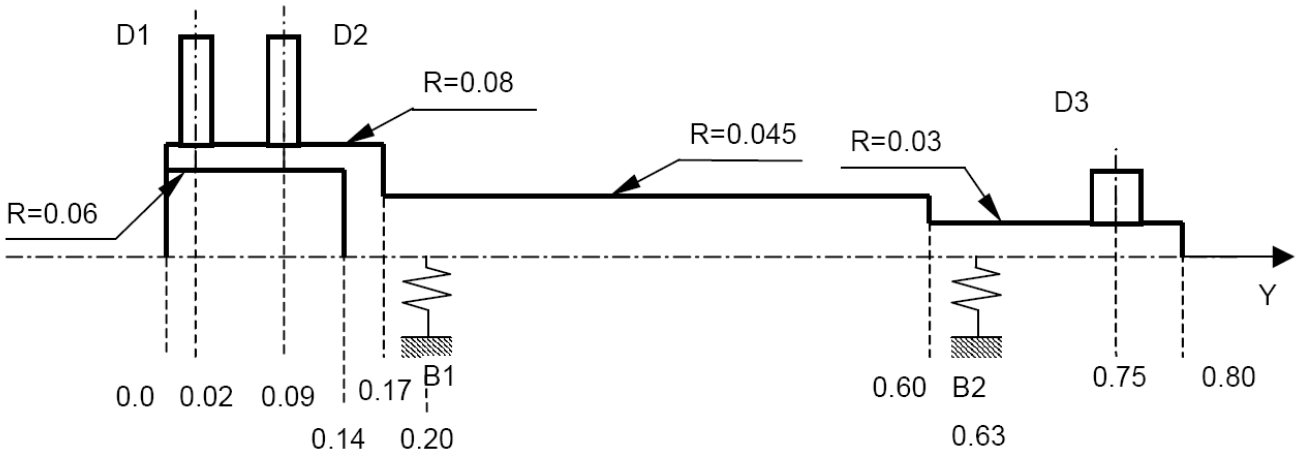
This test makes it possible to validate the calculation of the modes in rotation of a system of rotating shafts in the presence of stages whose characteristics in stiffness and damping depend on the number of revolutions.

In this test, one has a model of rotor with three discs, supported by two hydrodynamic bearings, whose matrices of stiffness and damping are nonsymmetrical and depend on the number of revolutions. This example is drawn from the handbook of qualification of ROTORINSA, [bib2], software finite elements intended to envisage the dynamic behavior of rotors in inflection.

1 Problem of reference

1.1 Geometry

A model of rotor supported by 2 stages (nodes $B1$ and $B2$ on the figure below), whose matrices of stiffness and damping are nonsymmetrical. It is composed of 3 discs and 4 sections of tree.



1.2 Properties of material

The geometrical characteristics and material are listed in the following table.

Material		$E=2\,10^{11}\,N/m^2$	$\rho=7800\,kg/m^3$	$\nu=0.3$
Disc	$D1$	$M=20\,kg$	$I_D=0{,}20\,kg\,m^2$	$I_P=0{,}40\,kg\,m^2$
	$D2$	$M=17\,kg$	$I_D=0{,}17\,kg\,m^2$	$I_P=0{,}34\,kg\,m^2$
	$D3$	$M=10\,kg$	$I_D=0{,}015\,kg\,m^2$	$I_P=0{,}30\,kg\,m^2$

The characteristics of the stages vary linearly according to the number of revolutions:

- with $5000\,tr/min$:

Stage $P1$

$kyy=9\,10^7\,N/m$	$kzz=5\,10^8\,N/m$
$kyz=9\,10^4\,N/m$	$kzy=-9\,10^4\,N/m$
$cyy=1{,}5\,10^5\,Ns/m$	$czz=4.5\,10^5\,Ns/m$
$cyz=-1\,10^2\,Ns/m$	$czy=1\,10^2\,Ns/m$

Stage $P2$

$kyy=6\,10^7\,N/m$	$kzz=1{,}5\,10^8\,N/m$
$kyz=8\,10^4\,N/m$	$kzy=-8\,10^4\,N/m$
$cyy=1{,}2\,10^5\,Ns/m$	$czz=1{,}9\,10^5\,Ns/m$
$cyz=-1\,10^2\,Ns/m$	$czy=1\,10^2\,Ns/m$

- with $6500\,tr/min$:

Stage $P1$

$kyy=1\,10^8\,N/m$	$kzz=4\,10^8\,N/m$
$kyz=1{,}5\,10^5\,N/m$	$kzy=-1{,}5\,10^5\,N/m$

$cyy = 1{,}3\,10^5\ Ns/m \quad czz = 3.3\,10^5\ Ns/m$
$cyz = -1\,10^2\ Ns/m \quad czy = 1\,10^2\ Ns/m$

Stage P2

$kyy = 7\,10^7\ N/m \quad kzz = 1{,}4\,10^8\ N/m$
$kyz = 1{,}3\,10^5\ N/m \quad kzy = -1{,}3\,10^5\ N/m$
$cyy = 1\,10^5\ Ns/m \quad czz = 1{,}5\,10^5\ Ns/m$
$cyz = -1\,10^2\ Ns/m \quad czy = 1\,10^2\ Ns/m$

1.3 Boundary conditions

To block the movements of type rigid body in the direction x, the degree of freedom is blocked DX with the node stage $B1$.

2 Reference solution

2.1 Method of calculating

Calculation modal were carried out on the beach number of revolutions going from 5000 with $6000\,tr/min$ with a step of $250\,tr/min$. To validate the correct taking into account of the linear variation of the characteristics of the stages according to speed, a calculation of Eigen frequencies is also carried out at the number of revolutions $5750\,tr/min$, which corresponds to the center of the beach speeds considered.

2.2 Sizes and results of reference

The results of Code-Aster give at the same time the frequencies of the modes of inflection, torsion and traction/compression. The number of calculated modes is 12.

2.3 Bibliographical references

- MR. LALANNE, G. FERRARIS, " Rotordynamics Prediction in Engineering ", Second Edition, Wiley, 2001.
- ROTORINSA, software finite elements intended to envisage the dynamic behavior of rotors in inflection, LaMCoS UMR5259, INSA-Lyon.

3 Modeling A

3.1 Characteristics of the grid

The rotor is with a grid in 21 finite elements of tree of the type POU_D_T and comprises 5 discrete elements of type DIS_TR for the modeling of the discs and stages.
Many nodes: 22
Number and type of elements: 21 SEG2
5 POI1

3.2 Sizes tested and results

The tests ensure to it not regression of the code. They relate to the first 12 frequencies, for the number of revolutions $5750\,tr/min$, for the two methods of calculating. They also test reduced damping.

The frequencies obtained by direct calculation at the number of central revolutions are in perfect adequacy with those obtained by interpolation inside the beach of variation number of revolutions.

4 Summary of the results

This CAS-test makes it possible to validate the taking into account of the hydrodynamic bearings whose characteristics in stiffness and damping depend on the number of revolutions.