SDLL128 - Line of trees with plateau characteristics depending on rotational speed

Summarized:

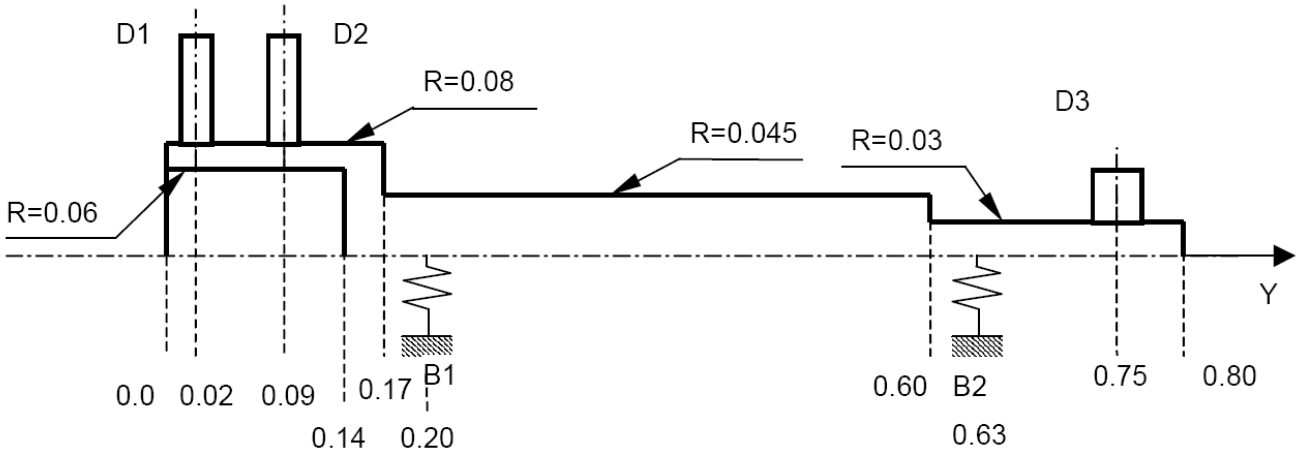
This test makes it possible to validate the computation of the modes in rotation of a system of rotating shafts in the presence of bearings whose characteristics in stiffness and damping depend on rotational speed.

In this test, there is a model of rotor with three discs, supported by two hydrodynamic bearings, whose stiffness matrixes and of damping are asymmetric and depend on rotational speed. This example is drawn from the handbook of qualification of ROTORINSA, [bib2], software finite elements intended to envisage the dynamic behavior of rotors in bending.

1 Problem of reference

1.1 Geometry

a model of rotor supported by 2 bearings (nodes $B1$ and $B2$ on the figure below), whose stiffness matrixes and of damping are asymmetric. It is composed of 3 discs and 4 sections of shaft.



1.2 Properties of the 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 bearings vary linearly according to rotational speed:

•with $5000\,tr/min$:

Bearing	$P1$	$kyy=9\,10^7\,N/m$	$kzz=5\,10^8\,N/m$
		$kyz=9\,10^4\,N/m$	$kzy=-9\,10^4\,N/m$
		$cyy=1{,}5\,10^5\,Ns/m$	$czz=4.5\,10^5\,Ns/m$
		$cyz=-1\,10^2\,Ns/m$	$czy=1\,10^2\,Ns/m$
Bearing	$P2$	$kyy=6\,10^7\,N/m$	$kzz=1{,}5\,10^8\,N/m$
		$kyz=8\,10^4\,N/m$	$kzy=-8\,10^4\,N/m$
		$cyy=1{,}2\,10^5\,Ns/m$	$czz=1{,}9\,10^5\,Ns/m$
		$cyz=-1\,10^2\,Ns/m$	$czy=1\,10^2\,Ns/m$

•with $6500\,tr/min$:

Bearing	$P1$	$kyy=1\,10^8\,N/m$	$kzz=4\,10^8\,N/m$

	$kyz = 1{,}5\,10^5\ N/m$	$kzy = -1{,}5\,10^5\ N/m$
	$cyy = 1{,}3\,10^5\ Ns/m$	$czz = 3.3\,10^5\ Ns/m$
	$cyz = -1\,10^2\ Ns/m$	$czy = 1\,10^2\ Ns/m$
Beari ng P2	$kyy = 7\,10^7\ N/m$	$kzz = 1{,}4\,10^8\ N/m$
	$kyz = 1{,}3\,10^5\ N/m$	$kzy = -1{,}3\,10^5\ N/m$
	$cyy = 1\,10^5\ Ns/m$	$czz = 1{,}5\,10^5\ Ns/m$
	$cyz = -1\,10^2\ Ns/m$	$czy = 1\,10^2\ Ns/m$

1.3 Boundary conditions

to block motions of type rigid body in the direction x , one blocks the degree of freedom DX with the node bearing $B1$.

2 Reference solution

2.1 Method of calculating

Of computation modal were carried out on the beach rotational speeds going from 5000 to $6000\,tr/min$ with a step of $250\,tr/min$. To validate the correct taking into account of the linear variation of the characteristics of the bearings according to the velocity, a computation of eigenfrequencies is also achieved by means of a rotational speed $5750\,tr/min$, which corresponds to the center of the beach velocities considered.

2.2 Quantities and results of reference

the results of Code-Aster give at the same time the frequencies of the modes of bending, torsion and tension/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 bending, LaMCoS UMR5259, INSA-Lyon.

3 Modelization A

3.1 Characteristic of the mesh

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

3.2 Quantities tested and results

the tests ensure non regression code. They relate to the first 12 frequencies, for rotational speed $5750\,tr/min$, the two methods of calculating. They also test reduced damping.

The frequencies obtained by direct computation at central rotational speed are in perfect adequacy with those obtained by interpolation inside the beach of variation rotational speeds.

4 Summary of the results

This benchmark makes it possible to validate the taking into account of the hydrodynamic bearings whose characteristics in stiffness and damping depend on rotational speed.