SDNV110 – Voluminal rotor in rotation around its axis, taken into account of the gyroscopy

Summary:

This test makes it possible to validate the calculation of the modes in rotation of a voluminal rotor with and without gyroscopic stiffness.

It is about a model of rotor, supported by two stages and in rotation around its axis. This example is drawn from the references [1] and [2].

The results of calculations are compared with those obtained with ANSYS . The results coincide perfectly with the reference solution.

Contents

1 Problem of reference

The objective of this case test is to validate gyroscopic modeling in 3D of a rotor (options MECA_GYRO and RIGI_ROTA) in Code_Aster.

One compares the results got by the modeling of Code_Aster with those obtained in ANSYS.

1.1 Geometry

One considers the rotor represented on the diagram below. It is about a tree length 0.3454 m and variable section, supported on two stages located respectively at the positions 0.1651 m (stage 1) and 0,287 m (stage 2). The rotor comprises a disc of ray interns 0.0203 m and of external ray 0.0495 m (thickness 0,028 m).

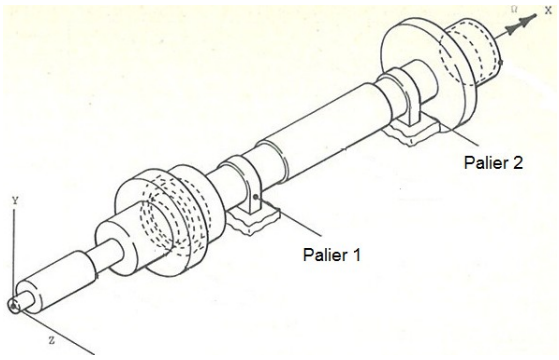

Image 1.1-1: Geometry of the rotor

1.2 Material properties

The cylinder has a density of $\rho = 7\,800\, kg/m^3$.
The Young modulus is $E = 207.10^9\, N\, m^{-2}$ and the Poisson's ratio is $\nu = 0,3$.

1.3 Boundary conditions and loadings

The tree rests on two stages (Palier1 and Palier2) having the following characteristics in stiffness:

- Configuration a: Kxx = Kyy = 4.378x10 ^{7} N/m, Kxy = Kyx = 0
- Configuration b: Kxx = Kyy = 3.503x10 ^{7} N/m, Kxy = Kyx = -8,756 x10 ^{6}

It is with the stop or in rotation at the speed of 100000 tr/min.

2 Reference solution

The reference solution is a calculation 3D carried out with ANSYS V14.

1. ANSYS V14.
2. H.D. Nelson and J.M. McVaugh, “The dynamics of Rotor-Bearing System using Finite Elements”, Newspaper of Engineering for industry, May 1976, pg: 593-600.

3 Modeling A

3.1 Characteristics of modeling

The rotor is modelled by quadratic voluminal elements (PENTA15 and HEXA20). It rests on two stages having the characteristics given by configuration A above.

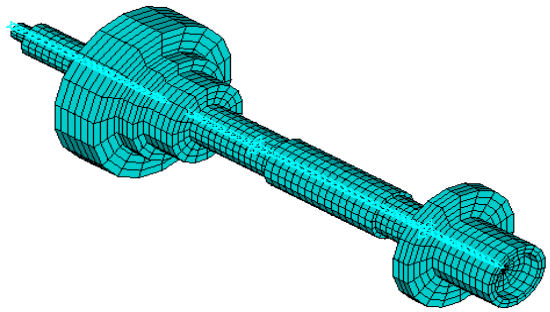

Image 3.1-1: Grid of the rotor

CALC_MODES calculate the modes suitable for stop (IE. without gyroscopic damping) and at several number of revolutions, IE. with gyroscopic damping (option MECA_GYRO), but by not taking account of the effect of softening by the stiffness (option centrifuges RIGI_ROTA).

3.2 Characteristics of the grid

Many meshs HEXA8	4230
Many meshs PENTA6	1386
Many meshs DIS_T	2

Table 3.2-1

3.3 Results: comparison enters calculations Code_Aster and ANSYS

For information, one gives below the results of the revolving machine to the stop.

Identification	Type of reference	Value of reference	Tolerance
Mode 1	'EXTERNAL'	416,38	4,00%
Mode 2	'EXTERNAL'	416,38	4,00%
Mode 3	'EXTERNAL'	772,65	1,00%
Mode 4	'EXTERNAL'	772,65	1,00%
Mode 5	'EXTERNAL'	1344,3	1,00%
Mode 6	'EXTERNAL'	1344,3	1,00%

Table 3.3-1: Summary of the results to the stop

The tables below give the digital values tested in this CAS-test. They is the Eigen frequencies with 100000 tr/min of the rotor pressed on its two stages.

Identification	Type of reference	Value of reference	Tolerance
Mode 1	'EXTERNAL'	52,23	7,50%
Mode 2	'EXTERNAL'	175,51	1,00%
Mode 3	'EXTERNAL'	496,09	2,00%
Mode 4	'EXTERNAL'	1032,4	1,00%
Mode 5	'EXTERNAL'	1824,8	6,50%
Mode 6	'EXTERNAL'	2438,5	3,00%

Table 3.3-2: Summary of the results tested at the speed of 100000 tr/min

4 Modeling B

4.1 Characteristics of modeling

The rotor is modelled by quadratic voluminal elements (PENTA15 and HEXA20). It rests on two stages having the characteristics given by the configuration B above.

CALC_MODES calculate the modes suitable for stop (IE. without gyroscopic damping) and at several number of revolutions, IE. with gyroscopic damping (option MECA_GYRO), but by not taking account of the effect of softening by the stiffness (option centrifuges RIGI_ROTA).

4.2 Characteristics of the grid

Many meshs HEXA8	4230
Many meshs PENTA6	1386
Many meshs DIS_T	2

Table 4.2-1

4.3 Results: comparison enters calculations Code_Aster and ANSYS

For information, one gives below the results of the revolving machine to the stop.

Identification	Type of reference	Value of reference	Tolerance
Mode 1	'SOURCE_EXTERNE'	360,23	3,00%
Mode 2	'SOURCE_EXTERNE'	416,4	4,00%
Mode 3	'SOURCE_EXTERNE'	653,07	1,00%
Mode 4	'SOURCE_EXTERNE'	772,68	1,00%
Mode 5	'SOURCE_EXTERNE'	1191,5	2,00%
Mode 6	'SOURCE_EXTERNE'	1344,4	1,00%

Table 4.3-1: Summary of the results tested with the stop

The tables below give the digital values tested in this CAS-test. They is the Eigen frequencies with 100000 tr/min of the rotor pressed on its two stages.

Identification	Type of reference	Value of reference	Tolerance
Mode 1	'SOURCE_EXTERNE'	45,36	6,50%
Mode 2	'SOURCE_EXTERNE'	148,76	1,00%
Mode 3	'SOURCE_EXTERNE'	446,59	2,00%
Mode 4	'SOURCE_EXTERNE'	1018,9	1,00%
Mode 5	'SOURCE_EXTERNE'	1824,8	6,50%
Mode 6	'SOURCE_EXTERNE'	2394	1,00%

Table 4.3-2: Summary of the results tested at the speed of 100000 tr/min

For information, the results are also compared with those given by a modeling 1D of the Beam type of Timoshenko.

Identification	Type of reference	Value of reference	Tolerance
Mode 1	'AUTRE_ASTER'	45,36	6,50%
Mode 2	'AUTRE_ASTER'	148,76	1,00%
Mode 3	'AUTRE_ASTER'	446,59	2,00%
Mode 4	'AUTRE_ASTER'	1018,9	1,00%
Mode 5	'AUTRE_ASTER'	1824,8	6,50%
Mode 6	'AUTRE_ASTER'	2394	1,00%

Table 4.3-3: Summary of the results tested at the speed of 100000 tr/min

5 Summary of the results

The cas-test implements the rotation of a tree pressed on two stages around its axis. Modeling 3D of the gyroscopy programmed in Code_Aster compared to the results got with the model are equivalent 3D is thus validated in ANSYS.