VALIDATION OF EXPERIMENTAL RIG WITH EMPHASIS ON DYNAMICS PHENOMENON OF ROTORS

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1 Introduction

The experimental rig consists of a horizontal rotor driven by an electric motor and a frequency inverter, and aims to simulate rotary machines providing a learning environment in rotor dynamics phenomenon that can occur in real machines. The first part of this study is to identify the six main natural frequencies and modes of rigid body vibration of the set of non-rotating parts of the machine. The second part of the evaluation is focused on the rotor, modeled through a software developed specifically for the analysis of rotors, where you can check the critical frequencies, examine ways of modes according to the rotations and generate Campbell diagram for analysis of other resulting characteristics of the gyroscopic effect.

Figure 1: Experimental Rig

2 Method

The methodology consists primarily of support the approach of the dynamics of non-rotating parts of the structure supported on springs and also the rotating parts (rotor).

$$M_r \left[\ddot{q}(t)\right]_r + \left(C_r + G_r\right) \left[\dot{q}(t)\right]_r + K_r \left[q(t)\right]_r = \left[F_{ext}\right]_r \quad (1)$$

Secondly, tests and simulations were performed with the purpose of obtaining machine characteristics. Simulations and tests:

- Simulation of the 3D model by the finite element method
- Frequency sweep tests
- Tests with initial displacement application
- Tests with application of impact on the discs

3 Results

The analysis of the dynamics of non-rotating parts has as a result the main modes of machine vibration.

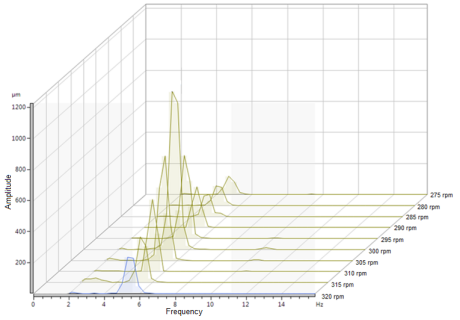

Figure 2: Test result to identify the translation mode in X direction. (Frequency sweep tests)

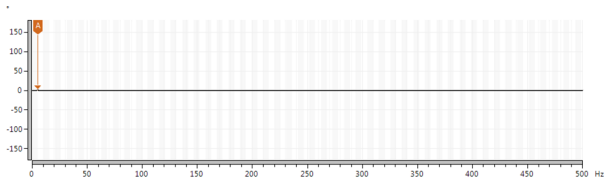

Figure 3: Test results to identify the translation mode in X direction. (Phase Spectrum)

Mode	Sweep Test (rpm)	Model Simulation (rpm)	Displacement Initial Test (rpm)	Average
Translation X	300,0	334,2	330,0	321,4
Translation Y	-	-	360,0	360,0
Translation Z	393,6	377,3	390,0	387,0
Rotation Z	431,4	433,8	450,0	338,4
Rotation X	506,4	480,6	510,0	499,0
Rotation Y	675,0	658,0	690,0	674,3

Table 1: Experimental and simulation results (non-rotating parts)

The rotor analysis begins with simulation results using the software ROTMEF® developed by CEPEL.

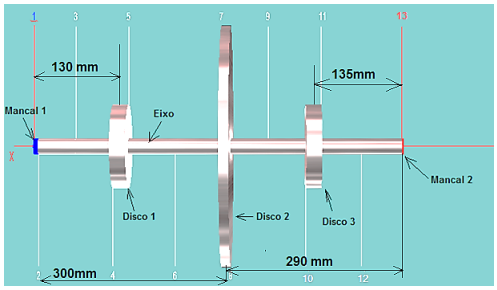

Figure 4: Rotor Model

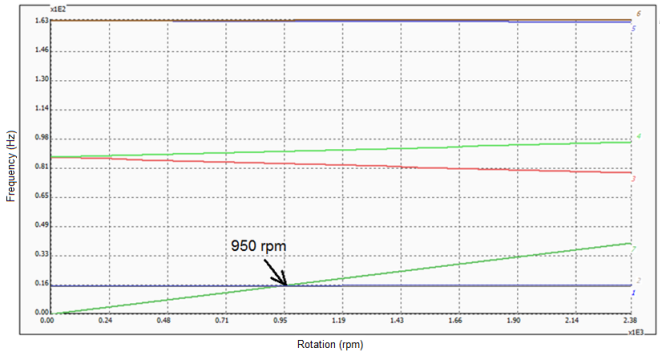

Figure 5: Campbell Diagram

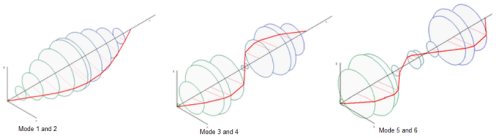

Figure 6: Modes Shape

The rotor dynamics analysis shows Full Spectrums and Orbits as a result of processing signals collected during the tests. By analyzing the results identifies the main rotor dynamics phenomena that the horizontal rotor presents.

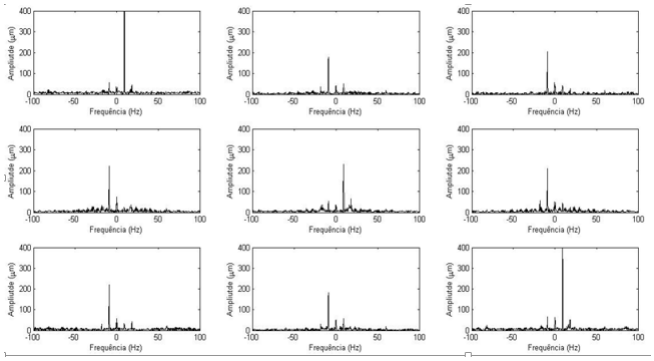

Figure 7: Tests results of first configuration in 550 Rpm (Full Spectrum Matrix)

Configuração 1 - 550 rpm - Frequências em Hz

1	Rotação	8,9	4	Rotação	9,1	7	Rotação	8,9
	Modo 1	-16,5		Modo 1	16,5		Modo 1	16,5
	Modo 2	16,5		Modo 2	-16,7		Modo 2	-16,7
	Modo 3	-82,3		Modo 3	-81,9		Modo 3	-82,9
	Modo 4	85,9		Modo 4	86,9		Modo 4	87,7

2	Rotação	8,9	5	Rotação	9,1	8	Rotação	9,1
	Modo 1	-16,1		Modo 1	-16,1		Modo 1	-16,3
	Modo 2	16,7		Modo 2	16,5		Modo 2	16,5
	Modo 3	-86,1		Modo 3	-81,9		Modo 3	-81,9
	Modo 4	91,1		Modo 4	86,7		Modo 4	88,5

3	Rotação	9,1	6	Rotação	8,9	9	Rotação	8,9
	Modo 1	-16,5		Modo 1	-16,1		Modo 1	-16,5
	Modo 2	16,5		Modo 2	16,5		Modo 2	16,7
	Modo 3	-81,9		Modo 3	-83,7		Modo 3	-81,9
	Modo 4	87,7		Modo 4	89,5		Modo 4	85,7

Table 2: Tests results of first configuration in 550 Rpm

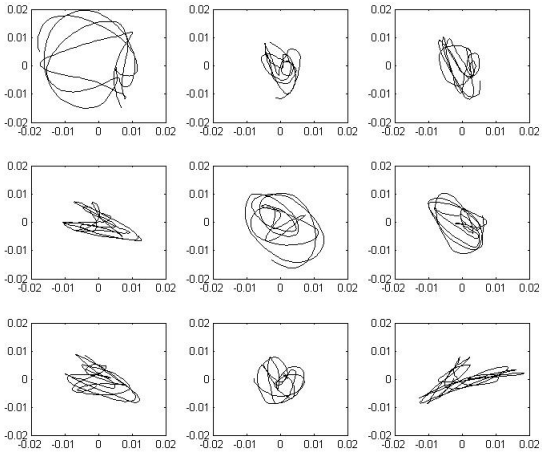

Figure 8: Matrix of Orbits the tests Configuration 1 - 550 Rpm

4 Conclusions

In the evaluation of non-rotating parts of the critical frequencies were identified as was also possible to correspondingly validating the first six vibration modes.

With respect to the horizontal rotor and the phenomena that the same features can be seen that the values are quite close to the values generated by Rotmef, then it can be concluded that the tests have expected results and about frequency analysis the gyroscopic effect can be observed and the presence of reverse modes by analyzing the full spectra.

It is considered that the horizontal rotor of the experimental rig has similar characteristcs of a real rotating machine and can be used for research and development in this field of mechanical engineering.

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