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Modeling a two-span rotor system based on the Hamilton principle and rotor dynamic behavior analysis

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Key words: Hamilton Principle, Two-span rotor system, Nonlinear seal force

Abstract

- A nonlinear dynamic model of a two-span rotor system is constructed based on the Hamilton principle and the Finite Element Method. The Musznyska model and the short bearing model are employed to describe the nonlinear seal force and oil-film force. The Fourth-order Runge-Kutta method is used to calculate the numerical solutions. The bifurcation diagrams, time-history diagrams, phase trajectories and Poincare maps are presented to analyze the dynamic behavior of the bearing center and the disk center in the horizontal direction.

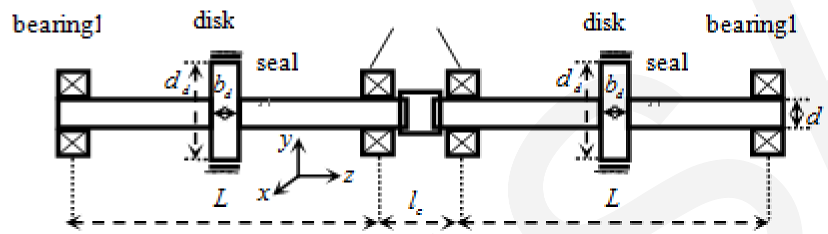

Fig. 1 The physical model of a two-disk and two-span rotor system

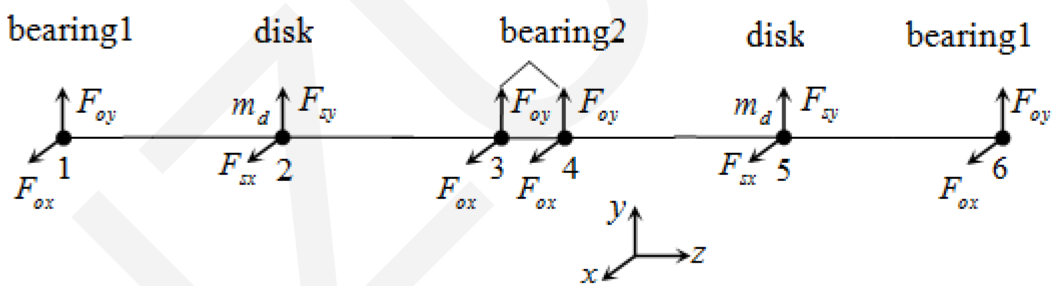

Fig. 2 The finite element model of a rotor system

The motion equation of the rotor system can express as:

$$\Omega^2 c_o M\ddot{Q} + \Omega c_o\left(\Omega\Omega + C\right)\dot{Q} + c_o KQ = F + G$$

Fig.3 shows the bifurcation diagrams at bearing1, bearing2 and at the disks.

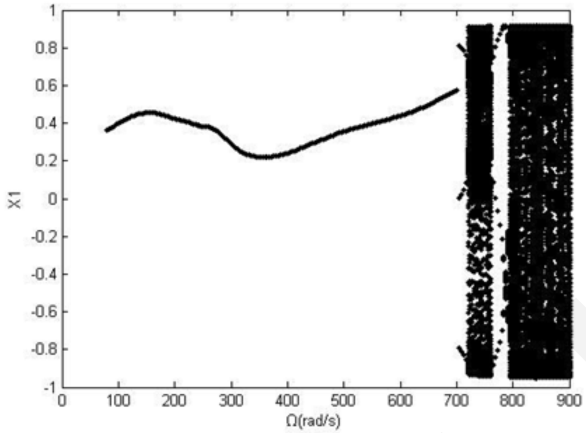

Fig.3(a) Bifurcation diagram at bearing 1

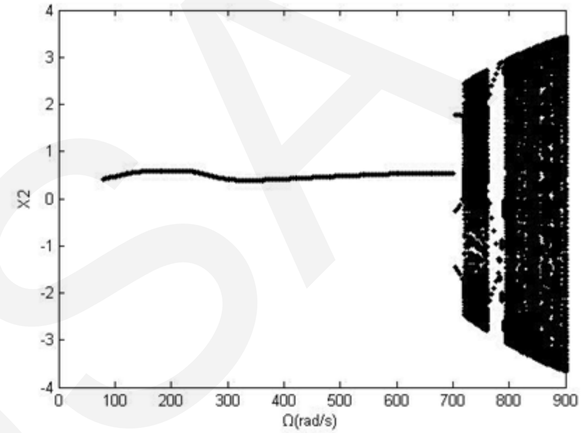

Fig.3(b) Bifurcation diagram at the disk

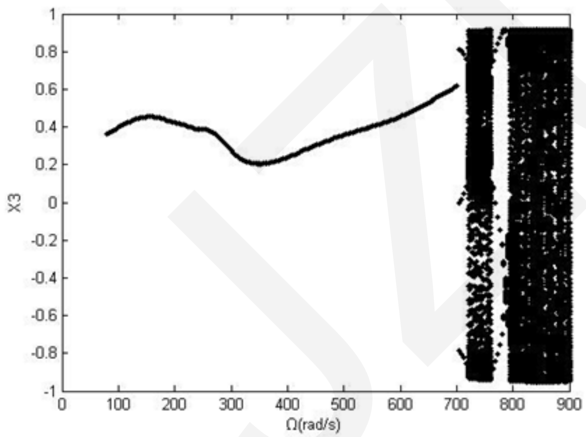

Fig.3(c) Bifurcation diagram at bearing 2

Fig.3 Bifurcation diagram with rotational speed increasing

- **At a lower speed, the rotor system motion is maintained steady, which is a periodic motion and the amplitude is limited. When speed is greater than 700rad/s, the system turns into a triple periodic motion.**
- **With increasing rotational speed, the response of the rotor system becomes more complicated, and the quasi-periodic motion and multi-periodic motion happen alternatively.**

Fig.8 show the quasi-periodic motion occurs at w=1400rad/s.

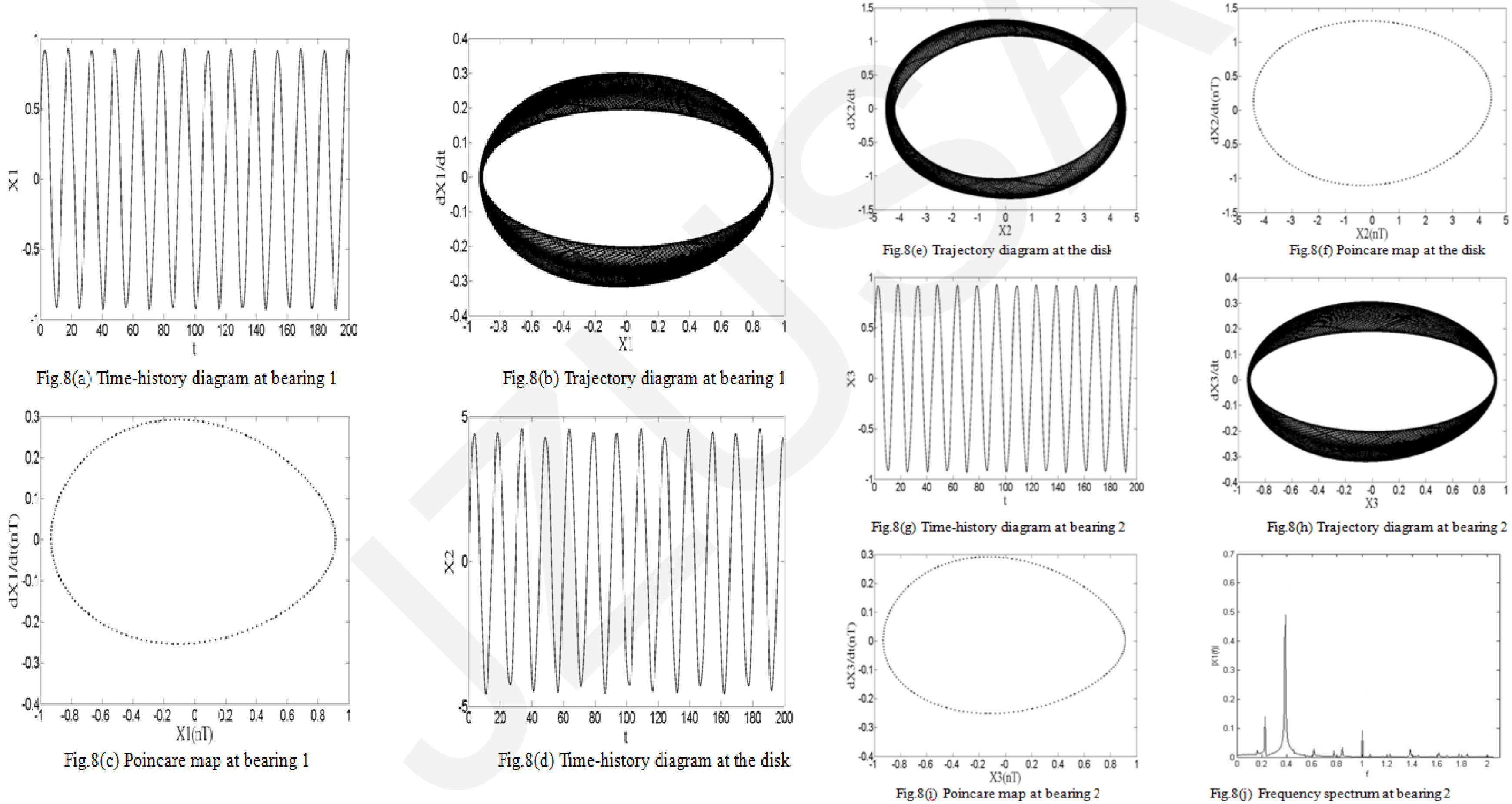

Fig.8 Numerical analysis results at $\Omega = 1400\, rad/s$

Conclusions

- Based on the numerical analysis, it can be concluded that the rotational speed, the nonlinear seal force, the oil-film force and the stiffness of the coupling have a great effect on the stability of a two span rotor system.

- This study can enhance understanding of the nonlinear dynamics of rotor systems and be helpful in choosing some designing parameters which affect the stability of the rotor systems.