Modeling of Rotating Shaft with Partial Rubbing

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Abstract

The rubbing phenomenon is one of the main malfunctions in rotating machines and causes the breakdown of machines. The rub-impacting vibration of a rotor system shows a very complicated phenomenon including not only the periodic motion but also the quasi-periodic and chaotic motions. When the rub-impact happens, the partial rub arises at first. During a whole period, the rub and impact interactions occur between rotors and stators (i.e. casings) once or fewer times. Gradual deterioration of the partial rub will lead to the full rub, and then the vibration will affect the normal operation of the machines negatively.

Because of serious damage of rubbing, many researchers have studied this problem from different aspects. Much attention has been given to the nonlinear dynamics of the rub-impacting rotor system. A contact force of rubbing between a rotor and a casing has been modeled as a piecewise linear spring and damper model. The relationship between the contact configurations and the generation of various kinds of vibration, such as "collision type synchronous vibration", "sub harmonic vibration", etc. has been studied, both theoretically and experimentally (Watanabe *et al*, 2005).

We have created the rotating machinery library by transfer matrix method in Modelica (Ishibashi *et al*, 2017). By transfer matrix method, the rotating shaft is decomposed into rotors, shafts, journals, couplings, housings and supports. The 5 DOF rotor dynamics model components have common faults of rotating machinery systems such as static and dynamic unbalance, shaft bending, and faulty bearing. The objective of creating this library is to carry out analytical investigations in order to gain some insight into the diagnostics of rotating machinery.

In this paper, rubbing components for partial rub are implemented in our rotating machinery library. Rubbing components in the one side contact case and the annular contact case are created for analyzing the several contact configurations respectively (Figure 1).

In the analysis of rubbing, models in which the rotor come into contact with the casing due to unbalance or models in which rotor is already contacting with the casing at rest are usually analyzed. However, in this research, the model in which the rotor come into contact from a non-contact state by an external force due to earth quake or flow-induced vibration is analyzed. The relationship between the contact configurations and the generation of various kinds of vibration is investigated (Figure 2). We validated the rubbing model in one side contact case with a rotor kit. By simulation, we reproduced the time history, the orbit and the full spectrum characteristics of the rotating shaft measured by the experiment precisely.

Keywords: Rotor Dynamics, Rubbing, Contact, Friction, Subharmonics

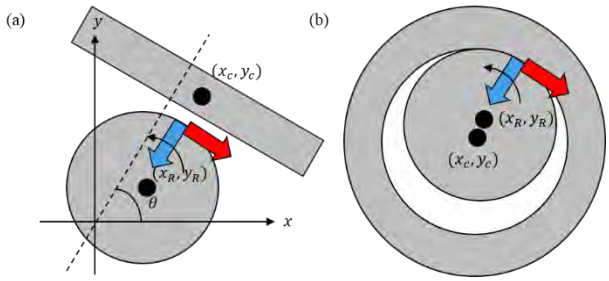

Figure 1. Type of Rubbing. (a) One side contact case. (b) Annular contact case.

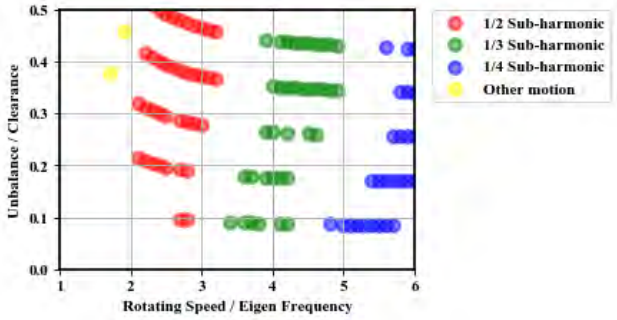

Figure 2. The domain of the rubbing vibration occurrence in the one side contact case.

References

Tatsuro Ishibashi, Han Bing and Tadao Kawai. Rotating Machinery Library for Diagnosis. *Proceedings of the 12th International Modelica Conference*, 2017. doi:10.3384/ecp17132381.

Yusuke Watanabe, Takuzo Iwatsubo and Keizo Awa. Study of Rotor Vibration due to the Rubbing against Casing. *Trans. JSME*, C 71, pp. 1421–1428, 2005 *(in Japanese)*. doi: 10.1299/kikaic.71.1421.