

Preface

The development of new rotating machines often encounters unexpected vibration problems. In many reported cases these vibration problems have had to be solved before the hydraulic performance of rotating machinery such as turbines, pumps, and compressors could be assessed.

The *v_BASE Databook* compiled by the Japan Society of Mechanical Engineers (JSME) contains a collection of vibration problems actually experienced in industry. Its first edition, published in 1994, includes 300 case studies. Almost two-thirds of the data case studies included in the first edition are related to rotating machinery, about half of which involve resonance. The authors learned the following lessons associated with the case studies:

1. Serious issues caused by large of rotational energy and centrifugal force:
A seemingly slight problem in rotor dynamics may produce very dangerous vibration in a body rotating at high speed, the same as the dynamics of a car running at high speed on a highway. Furthermore, apparently vibration is reproduced unless any repair is undertaken. This vibration problem, occurring once, can be eliminated only by making specific improvements at the designing and manufacturing stages, which may entail significant effort and cost for the final correct solution. Our rotor dynamics require us to be more practical in solving the issue to avoid encountering such a dangerous situation.
2. Knowledge versus practical experience:
Rotating machinery engineers must be accomplished with skills to achieve good machine operation, typically through balancing. Many engineers possess good theoretical knowledge of unbalance resonance phenomena through their basic engineering education. However, they may have apparent difficulty in applying that knowledge on site—for example, practical field balancing by scoping two waveform signals together with rotational pulses and rotor vibration, and reading the amplitude and phase difference without data analyzers. Such difficulty is most easily overcome by appropriate learning and experience to apply the knowledge to field practice without hesitation. Field experience in

eliminating vibration for troubleshooting based on variety of measurements and analyses offer the best educational opportunity. Experience is good teacher and the field is a good class.

3. Inertial (stationary) or rotating coordinate systems?

Rotor vibration is characterized by the gyroscopic effect. The term “gyroscopic effect” is related to the inertial coordinate system. On the other hand, the same phenomenon observed in the rotating coordinate system is called the “Coriolis effect” as per the theory of blade vibration. This example shows the importance of a unified and seamless understanding of both dynamics described in the inertial and rotating frames of reference. The bridge to connect the knowledge gap between rotor dynamics and rotating structure dynamics is provided in this book. The introduction of the complex displacement for the analysis of rotor whirling motion may also be an effective way to facilitate such understanding.

An effective approach to analyzing various phenomena thus benefits the understandable explanation for the correction of rotor vibration problems. The purpose of the present book is to describe the general mechanisms of resonance and self-excited vibration by using models that are as simple as possible, thereby forming a common basis for addressing various vibration problems. The study of these models will also be useful for enhancing intuitive ability. The authors have placed special emphasis on the conciseness of the mathematical formulations in the process of solving vibration problems. The entire content of the book is within the realm of linear vibration theory, but the authors believe, based on their experiences on-site and in consulting, that the book provides the sufficient body of knowledge needed for practical engagement. The book will also prove useful as test-preparation material for the ISO Machinery Condition Analyst (Vibration), i.e., an examination organized by the JSME in Japan.

Although the authors have endeavored to eliminate errors and provide appropriate emphasis, critical comments from readers are welcome. We are grateful to the authors of the literature cited in this book. Special thanks are also due to Prof. Hiroyuki Fujiwara (National Defense Academy, Japan) and Dr. Naohiko Takahashi (Hitachi, Ltd.) for reviewing the manuscript and providing valuable comments.

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On behalf of the authors
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