Vibration Analysis, Instruments, and Signal Processing (First Edition)
Jyoti Kumar Sinha
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The author is Dr. Jyoti Sinha, a reader (U.S. equivalent of Full Professor) in the Mechanical and Aeronautical Engineering Division at the University of Manchester in the United Kingdom. He has a career spanning more than 30 years with numerous publications in the field. The book is arranged in three sections over 10 chapters. The sections are divided into theoretical analysis (Chapters 2–4, and 8), instrumentation and signal processing (Chapters 5–7), and experimental applications (Chapters 9 and 10), covering "all three facets of vibration-based analysis" according to the author. It is intended to fill in the gaps for practitioners who may be strong in one area but lacking in the others. It is at a level appropriate for an upper division engineering student, but also has sufficient depth to interest the more experienced reader.

Chapter 1 provides an overview of the vibrational analysis problem and presents the roadmap to the rest of the book. The theoretical analysis section starts with Chapter 2, which introduces single degree of freedom (DOF) systems in terms of the damped harmonic oscillator, initially modeled by a mass-spring-dashpot arrangement. Examples with a mass loaded bar in both longitudinal and torsional motion are also given. The remainder deals with the transient and driven cases. Chapter 3 develops the basic concepts of the finite element method, using multiple DOF systems built from coupled mass-spring systems. From here, the mass and stiffness matrices are introduced, as well as element shape functions. This leads to the discussion of eigenvector and eigenvalue analysis and the computation of normal modes and mode shapes. Chapter 4 deals with solutions of the equations of motion. First, the direct integration (DI) method is discussed, and the Newmark-β scheme is used in three example calculations. Noting the problems in the DI approach, the mode superposition (MS) method is introduced and applied in a step-by-step manner to a two DOF system.

Chapters 5–7 cover instrumentation and signal processing. Chapter 5 begins with some general guidelines for setting up a measurement system and the considerations that go into the choice of sensors. This is followed by a discussion of sensor types and excitation sources. The remainder is concerned with the recording and digitization of data, specifically sample rate and bit depth, and provides some examples. Chapter 6 is an introduction to signal processing and discusses both time and frequency domain techniques. It introduces Fourier analysis and related concepts such as aliasing, filtering and windowing. The latter half covers statistical approaches to spectral analysis. The subject of Chapter 7 is experimental modal analysis, and it begins with a discussion of a multi-element measurement system and various excitation methods. It goes step-by-step through data acquisition, analysis and extraction of modal parameters. It then moves into specific cases such as beams, tubes and tanks.

Chapter 8 deals with the task of updating finite element models based on experimental results. The chapter is not out of sequence as it stands, but I would still group it with the theoretical section of Chapters 2–4. It is mainly concerned with the formal process of the sensitivity method and includes an example using a two DOF system. It concludes with a discussion of a cantilevered beam.

Chapters 9 and 10 close out the book by reviewing practical considerations and real-world applications of vibrational analysis. Chapter 9 focuses on rotating machines, primarily condition monitoring and fault identification. Chapter 10 concludes the book with a series of case studies taken mostly from the author's publications and presentations.

At the time of this review, the author is providing an erratum online at: http://personalpages.manchester.ac.uk/staff/jyoti.sinha/. These corrections apply to Chapters 4, 6 and 9.

The book has the admirable ambition of going from the basic theory through to practical applications. Unfortunately, it does not wholly achieve its goal. I find the book to be strongest in Chapters 7–10 which stem from the author's experience in the field. Chapters 2–5 are reasonably well-done, but are in need of more editing. In a few places, non-standard terminology is used, and there are mathematical details that would be difficult for the novice to grasp without further context (an appendix could have filled the void here). Chapters 5 and 6 are in more need of editing than the rest of the book combined. Chapter 5 has a lack of detail in the description of sensors, a poor explanation of gain and errors in the section on the 12-bit ADC. Chapter 6 has an overly simplistic discussion of filtering, and a treatment of Fourier methods lacking rigor. Both chapters contain figures that are poorly drawn or ill-conceived.

Those with some knowledge of the fundamentals may benefit from the more practical material that stems from the author's experience in the field. However, I cannot recommend the book for those looking for a general reference or unfamiliar with signal processing. Perhaps a second edition of this book will hit the mark.

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