Vibroacoustic Simulation: An Introduction to Statistical Energy Analysis and Hybrid Methods
Alexander Peiffer
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1 PURPOSE

The stated reason for this text was the author's conclusion that there was a need for a modern textbook on vibroacoustic simulation focusing on statistical energy analysis (SEA) and hybrid systems. The author notes that there are many good texts about acoustics and vibration. However, he feels there is insufficient treatment of the vibroacoustic simulation methods. This reviewer would summarize the purpose as providing a good foundation to SEA and hybrid simulations of vibroacoustic systems while relying on other texts to provide the details of acoustics, vibration, random systems, and the required numerical methods.

2 SUMMARY

This book attempts to cover the range of topics under vibroacoustic simulation with an emphasis on SAE and hybrid techniques. Even with 480 pages, this is an impossible task. The result is a clear presentation of the basic principles with enough detail for someone knowledgeable in the area to have a good introduction to SEA and hybrid simulation. This is not a book for those new to vibroacoustic analysis. The material is presented at a high level, and one must understand structural dynamics and wave theory to follow the terse presentation of the theory and mathematics. There is not sufficient detail for someone to learn how to apply SAE alone or with other techniques to solve problems. The presentation is done in a clear and logical fashion. The concepts presented should provide a good foundation for someone wishing to go further and apply SEA or hybrid simulation methods.

3 DISCUSSION

3.1 Linear Systems, Random Process and Signals

This first chapter is meant for those with some familiarity with dynamic systems. It begins with a damped one degree of freedom system and ends with multiple input multiple output systems. In many cases, this would be a one or two semester course. Without familiarity with the topic, this would be an intense chapter to work through. However, the treatment is well done and leads the reader through the understanding of problems of growing complexity.

3.2 Waves in Fluids

This chapter begins with basic fluid properties and runs through the wave equation to several specialized cases. This includes the treatment of plane waves, a piston in a wall, sound intensity, and many other cases. Using only 30 pages, this chapter is very dense with equations and concepts of acoustic propagation in fluids. For those familiar with the topic, this could make a good review. For those not familiar, this is a dense treatment and may take time to work through.

3.3 Wave Propagation in Structures

Beginning with the assumption that complex systems must be discretized to be modeled, this chapter moves from stress and strain models to waves and finally to energy methods. While the material is presented in quick steps, the process is thorough. It provides a good basic understanding of the formulations of finite elements.

3.4 Fluid Systems

The focus of this chapter is bounded fluid systems. The author describes how the principles from one dimensional system can be applied to multiple dimension cases. The chapter culminates with the introduction of acoustic finite elements.

3.5 Structure Systems

The concept of complex interconnected structures is introduced in this chapter. As is typically done, the development begins with a simple one-dimensional system and moves to two-dimensional systems of plates. The basic equations and concepts for Finite Element Analysis (FEA) are described here. However, since the focus is SEA the full approach is not developed.

3.6 Random Description of Systems

The concepts behind SAE are introduced in this chapter. Once again, the author moves from one-dimensional systems to the more complex. In addition, the concepts of diffuse fields and statistical analysis are used to form the basis for SAE. The chapter concludes with a discussion of SEA and the basic principles involved. As with the previous segments, this chapter is dense covering a lot of material in 40 pages.

3.7 Coupled Systems

As the title implies, this chapter focuses on coupled systems. Since the focus is on vibroacoustic systems, both structural and fluid coupling are discussed. The final segment treats combined FEA and SEA modeling approaches. While this is by no means a practical guide, the author does present the basic approach and considerations in working with hybrid simulations.

3.8 Coupling Loss Factors

A key part of SEA is the understanding and use of coupling loss factors. The chapter proceeds from simple beam model couple to more complex geometries. In line with the concept of the book, this is a treatment in terms of theory. There are no lists or tables of coupling loss factors. However, it does present a treatment that considers geometrical and other factors in understanding coupling losses.

3.9 Deterministic Applications

The fundamentals of acoustic modeling are covered in this chapter. From one-dimensional pipes through many of the classic acoustic components. These include Helmholtz resonators, micro-perforated sheets, mufflers, walls, etc. These treatments, while limited to only discussing the modeling approach, are well done and provide a good foundation for the analysis of such elements.

3.10 Application of Random systems

Unfortunately, this is a short chapter and does not have great depth or a lot of examples. In twenty pages the author manages to provide some illustrations of the use of SEA, but it lacks sufficient depth to provide more than an introduction.

3.11 Hybrid Systems

Building hybrid models of complex systems can be a complex task. This chapter sticks to the examples used previously and provides an overview of the process of assembling a hybrid model. The process shown is illustrative, but it does not provide a detailed example of a complex model. The discussion is useful but may leave some readers wanting more explanation.

3.12 Industrial Cases

There are three example cases discussed in this chapter: a commercial airplane, an automobile, and a train. Perhaps the chapter should have been titled Transportation Vehicle Cases. These are treated at a high level with an overview of the approach. Some discussion is presented of aspects illustrating the approach used with a hybrid model or comparing SEA and hybrid modeling solutions. This is much more a discussion of the strategy for approaching such models with consideration of aspects than a "how to" description for these sorts of problems.

3.13 Conclusions and Outlook

This concluding segment discusses the limitations of this treatment of the complex topic of vibroacoustic simulation. A few new approaches and some of the problems matching experimental and simulation results are discussed.

3.13.1 Basic mathematics

This chapter focuses on Fourier analysis and coordinate transformations. It provides basic formulations and describes the basic principles of these topics in a few pages.

3.13.2 Specific solutions

The solutions presented are related to specific geometries and wave types in various elements.

James K. Thompson, Ph D, PE, INCE Bd Cert
President, JKT Enterprises
JKT.JKTEnterprises@outlook.com