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BOOK REVIEW

BOUNDARY ELEMENTS IN ACOUSTICS, ADVANCES AND APPLICATIONS, 2000, by O. von Estorff (editor). Southampton: WIT Press, 480pp. Price £159, US$246. ISBN: 1-85312-556-3

This edited book has 14 chapters and it covers almost all aspects of the latest research on Boundary Element Methods (BEM) in acoustics. The authors are all prominent researchers in their respective areas, and most of them are from Europe. The book is intended to present advanced and state-of-the-art research topics on BEM in acoustics. As such, many of the derivations and explanations are aimed at advanced readers in related research areas. Fortunately, the authors of each chapter have done an excellent job in compiling an extensive list of references related to each individual topic. This has made the book a very good reference book for people who do research in related areas. This book is also intended to be a companion book to a more fundamental book announced on the back cover, *Boundary Element Acoustics, Fundamentals and Computer Codes*, T. W. Wu (editor), which is a tutorial book that contains some FORTRAN source codes for students and beginners. Some of the fundamental topics in these two books are indeed overlapping, but I consider them supplemental to each other.

In Chapter 1 (by von Estorff, Coyette, and Migeot), an introduction to linear acoustics is first presented. Then, the governing BEM formulations in acoustics are introduced. These include direct/indirect formulations, 3-D time-domain formulation, and the Rayleigh integral formulation. Some numerical implementation details are also provided.

Chapter 2 (by Migeot, Meerbergen, Lecomte and Coyette) presents some numerical implementation details, such as numerical integration on regular and singular elements. The numerical integration scheme presented seems to be for the direct BEM only. It would be nice if the numerical aspects of the variational indirect BEM were also included. Direct solvers and iterative solvers are briefly discussed. In addition, two frequency interpolation techniques that speed up matrix formation are introduced; one of them is the newly developed Padé-based frequency interpolation.

Chapter 3 (by Chen, Hofstetter and Mang) presents eigenvalue analysis using the BEM. The formulation is based on the particular integral method originally developed by Banerjee *et al.* The method is very similar to the dual reciprocity method.

Chapter 4 (by Mansur, Carrer, and Yu) is devoted to 2-D time-domain BEM. Contrary to what one might imagine, the 2-D time-domain BEM is actually more complicated than its 3-D counterpart (introduced in Chapter 1) because the influence of a source function is no longer restricted to the value at the retarded time. As such, integration in the time domain cannot be avoided. Fortunately, the time integration can be carried out analytically. Several alternative BEM formulations are presented. One of them adopts the Hadamard finite-part integral to provide a more compact expression. In addition, both constant and linear time variations are discussed. The authors have successfully overcome the difficulty associated with the use of linear time variation.

Chapter 5 (by Gaul, Wagner and Wenzel) is about hybrid boundary element methods derived from the Hellinger–Reissner principle. This is the topic that I believe most BEM researchers are not familiar with. The hybrid BEM formulations do produce symmetric

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matrices, which will facilitate fluid–structure interaction analysis. Both frequency and time-domains formulations are presented.

Chapter 6 (by Tröndle and Antes) first discusses a multigrid solver for the frequency-domain BEM. The multigrid solver is a combination of iterative and direct solvers, in which the direct solver is used on the coarse grid and the iterative method is used on the fine grid. The second part of the chapter is devoted to an efficient time-stepping scheme combined with an iterative solver for the 3-D time-domain BEM. The idea is to preserve the sparse matrix structure in the solution process. This part provides a follow-up to the 3-D time-domain BEM introduced in Chapter 1.

Chapter 7 (by Ochmann) presents the so-called "Source Simulation Techniques (SST)". The basic idea is to replace the problem by a system of acoustical sources placed in the interior of the structure. However, it should be noted that the acoustical sources are not necessarily the well-known point sources (in the form of the free-space Green function). The acoustical sources discussed in the chapter are the spherical wave functions that are fundamental solutions to the Helmholtz equation in the spherical co-ordinate system. Many different names have been used for SST. These include "method of fundamental solutions", "multipole method", and so on. The author has also related SST to the well-known Helmholtz integral equation by expanding the free-space Green function into spherical wave functions. In addition to SST, a multipole expansion is also briefly discussed for bodies of arbitrary geometry.

Chapter 8 (by Augusztinovicz and Tournour) is devoted to the inverse BEM, which is used to reconstruct the surface velocity on a given vibrating structure of arbitrary geometry. It is well known that inverse problems are ill conditioned. Therefore, regularization methods such as the Tikhonov regularization and the truncated singular value decomposition are required. The authors have found out that the inverse BEM has produced more accurate results at higher frequencies rather than at lower frequencies.

Chapter 9 (by de Lacerda, Wrobel, Power, Rêgo Silva and Mansur) reviews the thin-body BEM formulations for thin acoustic barriers. Both full- and half-space formulations are presented. In addition to the conventional rigid thin barriers, the barrier surface may have an impedance boundary condition. In that case, the dual boundary element method will have to be used. The authors also add an impedance boundary condition on the ground. The Green function then becomes more complicated than the half-space Green function obtained from the method of images. An integral form for such a Green function by Kawai *et al.* is adopted under such circumstance.

Chapter 10 (by McCulloch, Cremers and Guisset) shows a coupled FEM/BEM for acoustic transmission through baffled thin panels. The authors describe the phenomenon "acoustic transparency". Several practical application examples are given to demonstrate the method.

Chapter 11 (by Lerch, Kaltenbacher, Landes, Rausch and Eccardt) presents FEM, BEM and coupled FEM/BEM for a range of electro-acoustic transducers. Formulations in the fluid part include linear acoustics, acoustics in moving flows, and finite-amplitude non-linear acoustics. The transducers include piezoelectric transducers, electrostatic–mechanical transducers, and magneto-mechanical transducers. Several application examples are given. These include a sound protection shield, ultrasound flow meter, ultrasonic phased array antenna, high intensity focused ultrasound, and so on.

Chapter 12 (by Moosrainer and Fleischer) demonstrates the application of BEM and coupled FEM/BEM to the modelling of musical instruments. Two musical instruments, the guitar and the concert timpani, are chosen as examples. The numerical results are presented along with some discussion on important parameters related to instrument design.

Chapter 13 (by Homm and Schneider) is about underwater acoustics. In addition to BEM and coupled FEM/BEM, the authors also discuss SST and plane wave/local impedance boundary approximations. Some scattering examples are presented.

Chapter 14 (by Meulewaeter and Augusztinovicz) reviews the application of BEM for industrial problems. Some important issues, such as meshing, source description, and modelling of absorption, are discussed first. Several examples including engines, mufflers, and sound barriers are presented.

Overall, I have found this book interesting and informative. Although novice readers may not fully understand every single detail in every single subject, they may find useful information about the particular topic they are researching on. Also, browsing through the entire book may help readers broaden their view. I highly recommend this book to people who do research in acoustics and BEM.

T. W. Wu