

Preface to the Second Edition

It has been over 15 years since the first edition of this book was published. In that period, the use of models in the ultrasonic NDE field has seen a steady growth. Model-based ultrasonic NDE simulation packages were in their infancy when the first edition appeared, but now both research-grade and commercial software packages are available. Thus, it is more important than ever to understand the fundamental physics and mathematics behind ultrasonic NDE models. Another notable change has been the development of models to aid in the evaluation of NDE reliability and flaw detectability. This application of models has been termed model-assisted probability of detection or “MAPOD.” Also, starting in 2001 a series of ultrasonic benchmarks were sponsored by the World Federation of NDE Centers and the results presented at the annual Review of Progress in Quantitative NDE meetings. The aim of the benchmark studies was to validate modeling assumptions and compare the results of different modeling approaches to experiments on well-characterized samples. Such efforts, which continue today, are extremely important for models to gain a much wider acceptance and use by the NDE community.

Two books by the author have appeared since the first edition that can be considered companions and extensions of this book. The first book, *Ultrasonic NDE Systems—Models and Measurements*, coauthored with Prof. Sung-Jin Song, extended significantly the linear time-shift-invariant (LTI) system approach that appeared in the first edition of this book and showed how all the electrical and electromechanical parts of an ultrasonic NDE system (the pulser/receiver, cabling, transducers) could be characterized by models and the parameters of those models obtained with simple electrical measurements. These system elements were then combined to show how they produce the system function (or system efficiency factor) discussed in this book. The book with Prof. Song also provided a detailed discussion of Gaussian beam theory, parts of which have been modified and incorporated into this second edition because Gaussian beams have proven to be a highly effective ultrasonic beam model. That book also provided a new derivation of ultrasonic measurement models that has been adopted in this second edition

because of its simplicity and clarity. A second book, *Fundamentals of Ultrasonic Phased Arrays*, was written because phased arrays have become widely used in ultrasonic NDE tests and ultrasonic arrays possess modeling issues that have not been adequately addressed in a comprehensive manner. In that book, the Kirchhoff approximation and the leading edge response of flaws, both of which were discussed extensively in the first edition of this book, were also shown to be the foundations for understanding the flaw images generated by the synthetic aperture focusing technique (SAFT), the total focusing method (TFM), and the physical optics far-field inverse scattering (POFFIS) method—three of the most commonly used imaging methods.

While many modeling advances have been made since the first edition, there are some areas that still pose challenges. One is in the calculation of flaw scattering models. Certainly, the advances in computers in the last 15 years have made numerical flaw scattering calculations by methods such as boundary elements and finite elements more attractive. Still, the ability of such numerical methods to aid in the extraction of useful quantitative flaw information has remained limited. Also, there has been relatively little progress in quantitative flaw sizing since the appearance of the first edition of this book. The equivalent flaw sizing methods discussed in Chap. 15 have not been widely applied. Today, the simpler time-of-flight diffraction (TOFD) method and notoriously unreliable amplitude-based sizing methods remain the most widely used sizing methods. However, phased arrays offer a new way to effectively obtain the data needed for equivalent flaw sizing, so we have pointed out that possibility in Chap. 15.

In this second edition, we have kept the same general organization and philosophy of the first edition where we first discuss concepts in terms of fluid problems and then introduce the more complex models for elastic solids. While this results in some repetition, that redundancy is more than offset, in our opinion, by the ability to illustrate the results in a simple setting that still captures most of the essential physics involved. One significant change from the first edition has been in the introduction of MATLAB[®] functions and scripts.¹ The intention here was not to produce comprehensive modeling codes but to provide the means to evaluate key results involving beam propagation, scattering, and sizing. Since this is a book on “Fundamentals,” most of the content of the first edition remains intact. We have added new material on multi-Gaussian beams and provided an improved derivation of ultrasonic measurement models, as mentioned previously, to make the book more complete and up to date. A new chapter on how inspection modeling couples with the determination of probability of detection and reliability studies has also been included. The general ultrasonic measurement model of Bert Auld and the reduced measurement model developed by Bruce Thompson and Tim Gray remain the cornerstones of the ultrasonic models discussed in this edition. Although Bert and Bruce are no longer with us, their measurement models are lasting contributions to the ultrasonic NDE modeling

¹ MATLAB[®] is a registered trademark of the Math Works, Inc.

field. The leadership of the late Donald O. Thompson in developing NDE as a quantitative, scientific discipline has also been instrumental in the significant advances made by the NDE modeling community over the last 30 years. This second edition will hopefully help others to continue those advances in the future.

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