Journal of Pressure Vessel Technology

Book Reviews

Finite Element Procedures in Engineering Analysis, K. J. Bathe, Prentice-Hall Inc., Englewood Cliffs, N.J., 1982, 735 pp., $38.00.

The Finite Element Method (FEM) has assumed the role of a major force in analysis of complex problems in engineering. Beginning with structural analysis, FEM has migrated into heat transfer, fluid flow and electromagnetic problems. The book is written by a Master of FEM and is an outgrowth of a previous book by the author and one of his colleagues. The author's reputation stems from his being the father of ADINA (Automatic Design Incremental Nonlinear Analysis). As stated by the author, "The objective of this book is to present each of the various aspects of FE analysis and to provide a basis for the understanding of the complete solution problem when it is applied to problems in solids and structures, heat transfer, seepage, fluid flow and so on."

The book consists of 12 chapters divided into 3 sections. Chapters 1 and 2 introduce matrix method. Starting with simple operations, this progresses to vector spaces and subspaces, matrix representation of linear transformations and an introduction to Rayleigh quotient and minimax characterization of eigenvalues.

Chapter 3 treats some basic concepts of engineering. This includes analysis of steady state, eigenvalue problems, propagation of dynamic problems in time, analysis of continuous systems (differential and variational formulation, weighted residuals and Ritz methods). The concluding section considers imposition of constraints, i.e., penalty and Lagrange Multiplier method.

Chapter 4 and 5 deal with the basic formulation of the FEM including an introduction to beam and plates, bending elements and three-dimensional solid elements. Discussion of generalized coordinate FEM proceeds to an excellent description of generalized coordinate finite element models. Initiating the reader with the basics, the author then continues with the two and the more complicated three-dimensional elements. He then follows with Gauss points and Jacobian matrices. The author points out their proper place in the isoparametric formulation. The concluding section treats numerical integration and practical considerations in isoparametric elements. The author mentions calculation of stresses but alludes to the Campbell-Hinton interpolation scheme. The reviewer has found the latter to be most invaluable in determining stresses at the node points based upon calculated stresses at the Gauss points.

Chapter 6 concerns FE nonlinear analysis in solid and structural mechanics. For purposes of mechanics, a Lagrangian (material) formulation is used. The proper stress and strain tensors are then introduced plus the updating of Lagrangian formulations of nonlinear materials. Isoparametric elements are then employed in beam, plate, shell, plain-strain and plain-stress applications. In evaluating displacement and strain-displacement relations for various elements, it is pointed out that an evaluation of these kinematic relations is quite straightforward and yields an accurate description of the geometric nonlinear behavior of an element. At first, these relationships are applied to elastic materials and then to inelastic material behavior with special reference to elasto-plasticity and creep. The concluding sections consider collapse and buckling analysis, element distortions and higher order integration for nonlinear analysis. This is an interesting chapter and merits further reading.

Chapter 7 involves FE analysis to heat transfer, seepage, torsion and incompressible inviscid fluid flow. Journeying onwards, we next encounter the analysis of viscous incompressible fluid flow. This is formulated in terms of velocity-pressure. A brief discussion of the penalty method formulations conclude the chapter.

Chapter 8 concerns the use of various modern methods of analysis to solve large problems. Cholesky method, Gauss elimination, Gauss-Seidel interation method, Givens method and Householder method as required in the solution of static problem analysis. The chapter concludes with procedures in solving nonlinear equations using Newton-Raphson interaction approach and the quasi-Newton method plus the convergence criteria. An interesting chapter that should be studied.

Chapters 9 and 10 describe the direct integration method (Houbolt, Wilson and Newmark) used in solving the more difficult dynamic problems. Mode superposition follows with application to damping analysis (included and neglected). Continuing, direct integration methods are applied and their accuracies and shortcomings received. The important eigenvalue solutions, most important in reducing computer costs are presented. In addition, we next consider the approximate solution techniques of mass normalization, static condensation of nodes, Rayleigh-Ritz. The growing popular Lanczos method is next considered. The chapter concludes with a brief discussion of component mode synthesis.

Chapter 11 considers the vector iteration method and its variants plus the Jacobi, generalized Jacobi, Householder, QR iteration method and polynomial iteration schemes.

The final chapter treats solutions of large eigen problems. Although more concise than other chapters in this book, it is very informative. The author describes the determinant search method including preliminary considerations, solution algorithm and ways of implementing the determinant search method. The last but very important topic is subspace iteration. The chapter concludes with the preliminaries, convergence and interesting remarks on subspace iteration.

In summary, this is an excellent book. The author has not allowed the flavor to evaporate and disappear. This volume is very clearly written with proper explanations. The reviewer's advice is that the book should be read carefully. The book is recommended to both the novice and the experienced person. It belongs on the desk of anyone involved in FE analysis.

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Metallic Bellows and Expansion Joints: Part II, PVP Special Publication, Vol. 83, ASME, New York.

This volume is the second part in a series of special publications on metallic bellows and expansion joints. The first volume PVP-51 was published in 1981 by the Pressure Vessels and Piping Division of ASME, and sponsored by the Operations, Applications, and Components Committee. The first volume dealt principally with the analysis and testing of bellows expansion joints with respect to elevated temperature applications (with the exception of one paper that discussed the development of a thick shell expansion joint used in a steam generator). A considerable amount of outstanding experimental data is found in the first volume.

This second complimentary volume is principally devoted to design philosophy of expansion joints. Four papers address the design, analysis, and manufacture of expansion joints for heat exchanger applications. Three papers address the philosophy behind expansion joint application, specification, installation, and EJMA standards. The results of two separate test programs provide further data on which the designer may benchmark his analyses.

Stastny reviews the purpose of metal bellows expansion joints. Basic definitions of expansion joints that are available and their application in piping systems is explained. The requirement for anchors and guides in piping systems is presented as well as the data necessary to specify an expansion joint. Installation and in-service inspection recommendations are also included.

Reimus describes the contents and history of the Expansion Joint Manufacturers Association (EJMA) Standards. A complete summary of each section of the Standards is explained. An engineer involved in piping system and vessel design can easily determine whether the design and application of metal bellows expansion joints will aid him in his job performance.

Becht profides a history of the development of bellows analysis methods from early work in the 1940's to the present in his paper on Predicting Bellows Response by Numerical and Theoretical Methods. The state of the art is assessed and directions requiring further development are discussed such as nonlinear interaction effects for multi-ply and ring-reinforced bellows and numerical methods to predict bellows squirm, particularly at elevated temperatures.

Becht describes the design and analysis of a high-pressure, high-temperature bellows expansion joint design. Severe service requirements for a heat exchanger floating head expansion joint that exceeds the limits of standard expansion joints led to the study of a fabricated omega bellows. Criteria for elevated temperature effects are discussed and stress and buckling analyses are performed with shell analysis programs. In this instance, the author finds that ASME Code Case N-290 and EJMA standards contain some guidance; however, N-290 is applicable to nuclear reactors and EJMA does not address phenomena such as creep fatigue.

Thomas summarizes a test program which was conducted by the Expansion Joint Manufacturers Association (EJMA) to verify the design equations for circular metal bellows expansion joints. This paper describes the test program, compares the test results to those results obtained by the use of the design formulas, and summarizes the validity of the design procedure presented in the EJMA Standards.

Misvel and Chakrabarti provide a description of the design and a summary of the analysis for a convoluted shell expansion joint (CSEJ) that is used to reduce the thermal breeder reactor heat exchanger. Since the CSEJ is a thick wall shell, the performance criteria that apply to the expansion joint are for pressure vessels rather than for bellows criteria. The CSEJ is formed by machining from an electro-slag remelt (ESR) 2 1/4 Cr-1 Mo steel ring forging.

Habbar describes the application of a three-dimensional machining technique to a metallurgically homogeneous and clean steel forging as a first time usage for an expansion joint in a pressure vessel. This manufacturing and metallurgical solution to a large diameter thick wall expansion joint is applied to the Westinghouse liquid metal breeder reactor steam generator expansion joint (CSEJ). The advantages cited are: reliability, advantages of a straight tube concept, and ease in in-service inspection.

Merrick, O'Toole, Reimus and Bressler present results from a series of tests which demonstrate the feasibility of repairing bellows by welded patches, base metal repair, and contour grinding. Also included are the results of a test which demonstrates the capability of a bellows to withstand mechanical damage. Guidelines are presented which assist in the evaluation of a damaged bellows and its possible repair without replacement.

Brown reviews expansion joint concept considerations with respect to heat exchanger and other thermal expansion component applications. There is a discussion of the design parameter categories that an engineer might consider in the process of development from concepts to production for expansion devices to reduce the thermal interactive stresses in a heat exchanger. A number of active and passive expansion device types are discussed and a product evaluation criteria for selecting concepts with a higher probability of success for further evaluation is outlined.

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Impact, Fragmentation, and Blast, PVP Special Publication, Vol. 82, ASME, New York.

An area of study that has received increased attention over the last decade has been the study of impact, fragmentation, and blast phenomena relative to pressure vessels, piping, tubes, and rotating equipment. These studies have been motivated by a number of factors. First, most studies in the past have been oriented toward impact, fragmentation, and blast effects that excluded a range of data characteristic of industrial equipment dynamics (*velocities* ranging from 10 fps to 1000 fps and *fragment masses* ranging from grams to tons). Impact striking velocity has been generally classified into four regimes: Hertzian or contact, low (below 1000 fps), intermediate, and hypervelocities. Second, the development of computer technology and new experimental techniques are moving this technology toward a greater realization of better