Journal of Sound and Vibration (2000) **238**(5), 903–907
doi:10.1006/jsvi.2000.3328, available online at http://www.idealibrary.com on IDEAL®

BOOK REVIEWS

FLUID–STRUCTURE INTERACTIONS SLENDER STRUCTURES AND AXIAL FLOW, Vol. 1, 1998, by M. P. Païdoussis, London: Academic Press, xiv + 572 pp. Price £94.95 (paperback). ISBN 0-12-544360-9

Although the title "Fluid–Structure Interaction" is far more general than the contents of the book, Prof. Païdoussis did present a very wide coverage on axial-flow-related problems. Perhaps, Vol. 2 of the series would include the flow-induced problems.

This book deals with the dynamics and stability of cylindrical pipes with flowing fluid. Flow-induced instability is a major concern. The instability includes divergence, flutter, limit-cycle motion and chaotic oscillation. The treatment of each sub-topic proceeds from the very simple version of the system to the more realistic systems so that the readers would understand the problem before the applications. The book has six chapters and 11 appendices.

The preface answers two important frequently asked questions: "Why yet another book?" and "Why the relatively narrow focus?" The book is not just a collection of the relevant material but its style makes it easy to follow for both engineers and mathematicians. The relatively narrow focus enables the author to present and explain his material in a clear and step-by-step manner. Since only established material with little controversy is given, the readers will be quite comfortable to use it and to get a feel of the state of the art.

Chapter 1 is an introduction setting the overview and the scope of the related problems and of the book. The classification of flow-induced vibration is given as a by-product.

Chapter 2 is concerned with the concepts, definitions and methods. The physical concepts of simplifying a continuous flexible pipe conveying fluid to a discrete system of articulated rigid pipes and a double mathematical pendulum are illustrated. Essential mathematical and mechanical concepts of a matrix equation of motion, Newtonian or Lagrangian methods, holonomic and scleronomic constraints, singularity and eigenvalues, generalized and principal co-ordinates, Galerkin's method for conservative and non-conservative systems, and self-adjointness are discussed in brief and examples are given in many places. A brief account of fluid mechanics then follows. This includes the Navier–Stakes equation, Reynolds flow, potential flow, linearized flow, slender-body theory, turbulent flow and empirical formulations. Turbulent flow is studied in a statistical sense in more detail: Reynolds stresses, correlation and coherence, Taylor's hypothesis, spectrum and turbulence intensity, boundary layer, and K–ε model. Fluid loading concepts include added mass. Finally, the main difference of linear and non-linear dynamics is discussed in terms of buckling, flutter, pitchfork bifurcation, Hopf bifurcation, and phase-plane trajectories.

Chapter 3 sets out the formulation and the solution strategy for a much-simplified model: snaking motion of a hose predicted by linear dynamics. Governing equations of pipes having different boundary conditions are derived with emphasis on the Coriolis forces that can be easily overlooked. The negative stiffness mechanism of a buckled pipe conveying fluid is illustrated. Various bifurcation phenomena are discussed by the Argand diagrams of the eigenvalue: divergence via a pitchfork bifurcation of a conservative system, single-mode flutter of a circulatory system via a Hopf bifurcation, coupled-mode flutter via

0022-460X/00/500903 + 05 $35.00/0

a Hamiltonian Hopf bifurcation and the Paidoussis coupled-mode flutter. The governing equations are derived by Newtonian and Hamiltonian approaches. Various methods of solution are studied: determinant search and the Galerkin expansion. Both cantilevered pipes and simply supported pipes are discussed in details with the experimental data. Finally, long and articulated pipes are studied.

Chapter 4 extends the linear study to non-uniform pipes, sucking pipes, short pipes, and with harmonically perturbed flow. The governing equations are more complicated and closed-form solutions are not generally possible. Both analytical and experimental studies of conical pipes are given. Aspirating pipes for ocean mining are considered in detail. The collapse mode of a sucking pipe and the parametric resonance due to density pulsation for shallow immersion are illustrated. For short pipes, the shear deformation and rotary inertia become important. The analysis is actually an extension of the Timoshenko theory. After an extensive study on fluid dynamical forces, some applications are considered: the Coriolis mass-flow meter, hydroelastic ichthyoid propulsion, vibration attenuation, deep-water risers, piping vibration codes, vibration conveyance and vibration-included flow.

Chapter 5 considers the non-linear and chaotic dynamics of pipes conveying fluid. It is important to know what happens after the onset of instability. Equations are derived using non-linear axial strain and non-linear curvature. When the pipe is in vibration on a plane, two coupled non-linear differential equations are obtained after taking the first two terms of the non-linear strains and curvature. Damping is considered by using complex elastic modulus. Comparison with other work is given: Bourrieres, Rousselet and Herrmann, Sethna *et al*., and Ch'ng and Dowell. With a few rare exceptions, no general analytical solutions of the non-linear equations of motion are possible. A survey of the available numerical methods is given. Post-bifurcation phenomena for pipes with supported ends, articulated cantilevered pipes, continuous cantilevered pipes are studied. Special attention is paid to chaotic, non-linear parametric resonance and oscillation-induced flow.

The final chapter covers curved pipes with inextensional and extensional assumptions.

The appendices form an interesting part of the book. Notably, experimental methods for elastomer pipes, basic methods of non-linear dynamics and their applications for pipes conveying fluid including central manifold and normal form.

In summary, the reviewer found the book very easy to follow. Most of the material is essential. The book is recommended to research students and engineers working in the field as well as mathematicians who are interested in the applications of non-linear theory to fluid–structure interactions.

A. Y. T. LEUNG

AUTOPARAMETRIC RESONANCE IN MECHANICAL SYSTEMS, 2000, by A. Tondl, T. Ruijgrok, F. Verhulst and R. Nabergoj. Cambridge, England: Cambridge University Press, xiv + 206 pp. Price £35, US$ 59.95. ISBN 0 521 65079 8 (hardback)

This new book is entirely devoted to the study and elucidation of autoparametric vibration phenomena within mechanical systems and is intended to suit a wide readership, albeit one with a definite interest in the application of autoparametric systems within mechanical engineering. The authors have gone to considerable trouble to emphasise a generally integrating objective for this book, taking mechanical engineering as the core applications area. From this standpoint, physical models and mathematical treatments are introduced in a logical and progressive fashion in order to build up depth and breadth of understanding. The mathematical treatments are rigorous, yet reasonably assimilable by anyone prepared