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Book Reviews

Machinery Noise and Diagnostics, R. H. Lyon, Butterworth Publishers, Stoneham, MA 02180, 1987, 299 pages, $42.95.

Reviewed by H. Saunders

This book is a gem! The field of noise control developed very rapidly in the past two and a half decades. The control of noise must be contemplated in all stages of design in the engineering of (*a*) industrial and office machinery, (*b*) structure and engines (aircraft, power plant and automotive), (*c*) propeller noise, (*d*) home appliances, and (*e*) other sources of noise in the immediate environment. At one time, engineers controlled noise in general by common sense or trial and error. Noise sources stem from a number of different areas. They are (*f*) of aerodynamic origin, (*g*) structures and their vibration, (*h*) pumping liquids in transforming and transporting of mechanical power, (*i*) vibration and shock isolation, and (*j*) problems of structural fatigue caused by sound and vibration. Requirements for improved instrumentation are a prime necessity in measuring noise and vibration analysis. The book focuses on major forms of machinery noise reduction. Transmission of noise can be reduced by modification of shafts, bearing supports, frames and other types of machine elements by alteration of mass loadings and compliances at certain critical locations. One can lower the sound radiation of structures by reducing the vibration amplitudes of panels and housing plus curtailing the structural coupling to the surrounding air. As stated by the author, "The book is intended to help the engineer develop a feel for these processes and to be able to predict the effects of structural changes in vibration transmission and sound radiation . . . . This book differs from many noise control books by the absence of discussion of add-on or "band-aid" noise control devices . . . . Our motivation is to design machines that will produce less noise."

The book consists of 8 chapters and 3 extensive appendices. Appendix A explains relevant mathematics (Fourier series and integral transforms, frequency analysis, Z transforms, Hilbert transforms, power spectra and cepstrum). This continues with criteria for machinery noise and vibration, hearing loss, loudness of machinery noise, criteria for vibration, communication in the work place and that based on perceived quality. Appendix C determines transfer function for measured data.

Chapter 1 introduces the reader to machinery noise. The book states the goals and general features of noise reduction. This includes cost assessment, approaches to diagnostic system design, classification in methods of detection. Machine faults can be ascertained by modern-day equipment. All this is discussed in greater detail in later chapters.

Chapter 2 explains the sources of vibration. They stem from unbalance in machinery, reciprocity unbalance (crank and slider mechanisms) and impact of machinery. The author employs diagram elements in mechanical and electrical systems. They represent their connectivity and dynamics. An example of impact dynamics is piston slap in diesel engines. Other important sources of vibration are gear meshing, noise generated by fluctuating magnetic forces in motors and generators plus the shedding of turbulence by obstacles in a flow stream.

Chapter 3 continues with structural response to excitation. Examples are illustrated by the wave motion (flexural and longitudinal) in a structure. The author details the mobility of a finite rod accompanied by lucid type models. This includes the action of structural damping. This forges ahead with the measurement of power flow in bending waves. The latter may be measured in model gear striations and finite structures. The basic response of a single degree of freedom system leads to structural response. This continues with resonances of a finite bending beam and the effects of curvature on modal density, unbalance, a more detailed consideration of mobility, transfer function, power transmission in machine type structures, and the performance of isolators on flexible structures.

Chapter 4 dwells upon vibration transmission in machine structures. "Two port" method analyzes the former. This guides us to the condition of joining of system components (mathematically) with direct application to a diesel engine plus noise transmission through structural junctions. We next encounter the analysis of transmission line finite elements in matrix form. The author derives his well-known theory of statistical energy analysis (SEA) of a duct with specific mention of coupling loss factor (measurement of power flow or damping effect when one system is attached to another). The book furnishes a good example of noise transmission in a ship structure and then compares calculation of transmissibility as a function of incidence angle. This provides a direct application and employment of SEA in organizing vibration data. A good thought-provoking channel!

Chapter 5 gets down to "brass tacks." After studying transmission of vibration through a machine to its outer surface, we now experience the action of sound radiated by machines. To introduce the subject of radiation of sound, an analysis is made of a one-dimensional longitudinal vibration of a rod. Plane wave radiation opens the chapter with sound from (*a*) vibrating sphere, (*b*) turbulent mixing in region of a jet, (*c*) muzzle blast of a firearm, (*d*) torque applied to a disk in a fluid, and (*e*) radiation from colliding parts or impact of two spheres. This progresses to specific acoustic mobility and sound intensity with measurement of sound power by the latter. Then, we encounter the sound power in a reverberating room plus the procedure of employing reciprocity to measure sound radiation in a small reverberation chamber. An additional important factor is the measurement of sound radiation from and by structural surfaces with corresponding radiation from structural bending waves. This engenders the aspect of

radiation below the critical frequency plus using numerical methods as an alternative to experimental endeavors for determining sound radiation. The author employs full blown mathematics in explaining these phenomena.

The next chapter develops the application of signal energy, i.e., mean or integral square of the signal resolved into narrow or broad band frequency. In order to measure noise in a rotating fully assembled machine, vibration and acoustic information must be obtained during operation. Faults in a rotating machine consider employment of an envelope method in measurement of high frequency resonance and gear transmission errors from noise data. The powerful cepstrum method separates the source and path from each other. This also furnishes a smoothing procedure by extracting the low time components of the cepstrum plus separation of different frequency multiples in a complicated spectrum. Excellent examples consider diagnostics of a horizontal centrifuge, valve and valve-seat impacts with an expanded analysis of valve resonance. An inverse filter could be employed in undoing spectral distortion due to propagation in the valve-valve seat impact. The chapter ends with the aspect of uncertainty in vibration transmission due to a distant location from the source plus the re-evaluation of transfer function behavior in structures due to their low modal overlap.

Chapter 7 opens up with the topic of diagnostics using signal phase and discusses the recovery of a temporal wave form of a source of vibration and the diagnostics that employ the phase of a signal. The initial topic studies experimentally cylindrical pressure waveform recovery via pressure transducer. The experimenters accomplish this by drilling a hole in the head of a diesel engine. Cepstrum analysis rears its head by separating a source and path characteristics in the diesel engine problem. Structural problems could affect the transfer function phase but mathematical relations permit us to relate the phase to other measured quantities. A good example would be to compare the phase of the transfer function with the phase delay of a bending wave between source and receiver. An interesting discussion of the poles and zeros of a transfer function are in order with due explanation of the drive point system functions. We now venture forth in expanding the phases in one-dimensional acoustic pipe and two-dimensional rectangular rooms. The next topics report on experimental studies of phase travel in a plate and the phase variability of the structural transfer function of an engine structure. The final section shows how it is possible to relate the phase and log magnitudes via Hilbert transform of a lightly damped structure.

The final chapter covers advanced topics in diagnostics using machine monitoring systems. The possibility of designing a diagnostic system using wave form recovery would be in the future. However, much remains to be accomplished in achieving such a system. Future diagnostic system design and application require the adaptive processor. This is hampered by the tremendous expense of both hardware and software. The chapter concludes with the identification of systems employing orthonormal functions, i.e., Laguerre and Hermite functions. The former has problems concerning large number of terms in obtaining the proper order of the frequency spectrum or complexity in the impulse response. Hermite functions don't have this problem with respect to representing the transfer function. Work is in progress in attempting to utilize Hermite function expressions in system representation.

In summary, this is an excellent book. The author accomplishes his goal and more. The reviewer would have preferred seeing (*a*) table of nomenclature (aid to reader), (*b*) relation of modal analysis to acoustic intensity, (*c*) transfer matrices applied to acoustics, and (*d*) more elaborate examples in the excellent acoustic intensity section. Furthermore, the reviewer feels that in the bibliography section for journals, this publication, the *Journal of Vibration, Acoustics, Stress Analysis and Reliability in Design*, should have been included. A number of excellent papers have been published in our journal. Nevertheless, the reviewer does recommend this book to those interested in tackling the problem of machinery noise reduction.

Tubular Members in Offshore Structures, W. F. Chen and D. J. Han, Pitman Publ. Co., distributed by Longman's Inc., 95 Church Street, White Plains, NY, 1985, 371 pages.

This book delves into the inelastic behavior and buckling performance of tubular memebers. This information is absolutely essential in assessing realistically the strength and risk in offshore structures. Most tubular members undergo a combination of flexural and axial loads in offshore structures and must be treated as beam-columns. In solving the latter, virtually all available techniques (experimental and analytical) are used. They range from the simple to computer-based methods which incorporate material and geometrical nonlinearities. As stated by the authors, "This book has been planned so that it can be used as a text for the practitioner and as a reference work for the research worker. The purpose of this book is to . . . (*a*) review the course of research on cylindrical beam columns as used in offshore structures, (*b*) discuss the beam-column problem to highlight the particular difficulties associated with cylindrical tubes in offshore structures, (*c*) present analytical techniques that are capable of dealing with tubular members in framed structures, and (*d*) show how existing design rules can be improved and new design rules can be developed".

The book consists of 8 chapters. Each chapter contains an excellent set of references.

Chapter 1 introduces the book and details the information to be furnished in later chapters. The chapter continues with the plastic response of tubular sections as described by four parameters, i.e., moment, thrust, axial deformation (cycle buckling and straightening) and curvature. The current AISC-CRC column curve and interaction formulas can be employed in the design of tubular columns in offshore structures. However, there is a need for developing an analysis capability for predicting the strength and behavior of these members. The action of external pressure due to hydrodynamic consideration may significantly reduce the axial load carrying capacity of these tubes to less than predicted by AISC-CRC column curve. The authors review the Shanley model curve for beam columns and furnish their basic assumptions. The book considers limit state design. The basic aim is to provide a reasonable margin of safety for the structure upon entering a limit state (plastic deformation).

Chapter 2 derives the moment-curvature relations between moment (M), axial load (P) and curvature (ϕ) for the beam column behavior. The pure bending ($M-\phi$) relationship is derived for both elastic and plastic regions. This leads to the derivation of the $M-P-\phi$ relations, boundaries of stress state and simplified $M-P-\phi$ relations in the elastic-plastic region. The tangent stiffness method (TSM) divides the tube into cross sections (small elements) and obtains total axial force and bending moment by summing up the effects of stresses on all elements. The book continues by introducing effective Young's modulus and employs the Tresca yield diagram. Residual stresses are then considered and Marshall proposes a simplification of the slicing method. This compares favorably with the hole drilling technique. A computer subroutine (TANGENT) calculates the generalized strains for a given stress increment step-by-step. Residual stresses significantly reduce the stiffness of cross sections in the