Book Review

Applied Theory of Vibration Isolation Systems, by K. V. Frolov and F. A. Furman. Translated by E. A. Zharkova. English Edition Editor E. I. Rivin. Published by Hemisphere Publishing Corp., New York, NY, 1990

This book is an English translation of a book that was originally published in the USSR in 1980. The principal author, K. V. Frolov, is Vice-President of the former USSR Academy of Sciences and Director of the A. A. Blagonravov Mechanical Institute. His work has been in the area of machine dynamics and vibrations in engineering, with a focus on designing machines and mechanisms using optimal vibration levels as a criteria. He has also made important contributions on the study of man–machine system dynamics. The text gives Western researchers access to material which has not been readily available until now.

The text begins with the usual review of the types of vibration: harmonic (periodic with a single frequency), polyharmonic (periodic represented as a sum of harmonic frequencies), random, and shock. The descriptions are brief, for example, random vibration is described in about six pages, and shock in three pages. As such, the descriptions are adequate for readers already familiar with the terminology, but too brief for a newcomer in the field.

Thirteen pages of Chapter 1 deal with specifications for vibration protection systems for machines and equipment—standards on occupational vibrations. The author is primarily concerned with standards dealing with human exposure. He discusses seated passengers, seated operators, standing operators, and hand-held machines. Some discussions of vibration perception, and the harmful effects of vibration is in this section. Operator performance levels under vibration is discussed. Permissible vibration levels from standards of various countries is presented.

The last 19 pages of Chapter 1 deal with the biomechanical characteristics of a human body and the requirements of vibration protection systems for an operator. This is an interesting and useful part of the book. Much data are summarized. Examples include: (1) mechanical properties of human tissues, (2) stress–strain curves for human bone and tissues, (3) models of the human body, (4) frequency response functions of the human, (5) the response of the human body to vibration, and (6) the perception of vibration by the human. Tables and plots of mechanical impedance for the human in many positions are given. Examples include sitting in various positions, standing in many positions, kneeling, lying down, and hand-held equipment.

Chapter 2 discusses linear vibration isolation systems. The chapter starts with the usual single degree of freedom model. Nonlinear isolators are introduced, with the analysis at this point being the linear analysis of small oscillations near the equilibrium position. Only damping proportional to velocity (viscous) is considered. The response to harmonic, polyharmonic, and random vibration is considered. The response to shock is treated at this point as the response to an equivalent impulse. The much-used concept of the Shock Response Spectrum (SRS) in Western literature is not mentioned in this book.

Next, the linear vibration of isolated systems with several degrees of freedom are discussed. Several examples are given, up to about 3 degrees of freedom. The vibration isolation of elastic bodies is then discussed. This discussion is very theoretical, with few examples. The last 14 pages of this chapter are devoted to the linear vibration of isolation of systems with distributed parameters. This chapter also introduces the dynamic characteristics of hydraulic elements, which are used in a later chapter on active control.

Chapter 3 introduces the reader to nonlinear

Shock and Vibration, Vol. 1, No. 1, pp. 95–96 (1993)

CCC 1070-9622/93/01095-02

vibration isolation systems. Most of the discussion concerns nonlinear phenomenon that have undesirable effects on isolation systems. This is useful information for those of us who tend to design using linear theory, and tend to forget that nonlinear behavior can seriously degrade the performance. Topics include discussions applied to isolation systems of:

- Subharmonic resonance—Subharmonic oscillations of order 1/3 and 1/2 are discussed.
- Parametric vibrations—The system chosen for study is the vibration isolation of a pivoted body.
- Self-excited vibrations—Topics include limit cycles, quasilinear systems, and relaxation vibrations. It is interesting that the concept of phase space is used in this section to describe limit cycles, but is not used in the later section dealing with active controls.
- Synchronization—This section discusses the synchronization of natural vibration with external excitation frequency.

A short section deals with nonlinear vibration of systems with several degrees of freedom. The system studied is a solid body mounted on several isolators. Equations are given, but not many practical results. The nonlinear vibration of isolation system with distributed parameters is discussed. The example discussed is for high-frequency vibrations in a hydraulic isolation system.

Chapter 4 discusses active vibration isolation systems. The discussion centers on analog control systems with an emphasis on systems using hydraulic exciters. Many examples of isolation systems using hydraulic exciters are given. The nonlinear effects of hydraulic exciters on a controlled isolation systems is discussed in some detail. Self-excited vibration and their abatement is discussed relative to hydraulic exciters. Resonance interactions between a nonlinear mechanical system and a hydraulic component is given some attention.

Active vibration control is a topic of much recent research. Unfortunately, the age of the text (originally published over ten years ago) is evident. The author does not mention the modern state space representation of control systems, nor does the text discuss control of sampled systems which is a topic of much recent interest. The exclusion of much of modern control theory will limit the usefulness of this chapter.

Chapter 5 covers optimum vibration isolation systems. Two classes of methods for searching for an optimum solution are discussed: random search methods where the parameter space is searched in a random fashion, and deterministic search methods where trial parameters are searched in a deterministic manner depending on the results of the previous trial. As expected the material builds on the previous chapters, that is, the emphasis is on hydraulic exciter active systems, with some discussion of a vibration isolation system for human operators.

The book should be most useful to those who have an interest in isolation systems using hydraulic actuators for active control, and those with an interest in the design of isolation systems involving human operators.

Reviewed by:
David O. Smallwood
Sandia National Laboratories, Experimental Structural Dynamics Department,
Albuquerque, NM