

Article

Shock Vibration Control of SDOF Systems with Tubular Linear Eddy Current Dampers

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Featured Application: In this work, the transient response of a single-degree-of-freedom (SDOF) system with a tubular linear eddy current damper (TLECD) under shock excitation is calculated and analyzed. Moreover, to achieve the best design and performance assessment of the structural shock vibration control by the TLECD, this study introduces the shock response spectrum (SRS) and a straightforward design flowchart of the TLECD for its mechanical characteristics.

Abstract: The nonlinear dynamic characteristic of a tubular linear eddy current damper (TLECD) and the transient responses to shock excitations of a single-degree-of-freedom (SDOF) system with the TLECD are studied. First, the nonlinear force-velocity relationship of the TLECD is discussed using the finite element simulation and mathematical model fitting. Next, the influences of three forms of shock excitation and various mechanical parameters of the TLECD on shock vibration control of an SDOF system with the TLECD are investigated. Moreover, for the SDOF systems with the TLECD or the nonlinear fluid viscous dampers (FVD) at the same maximum displacement and maximum damper force, the time to reach the maximum displacement, the time to reach one-third of the maximum displacement, the energy input of the external loading, and the energy dissipation of dampers are analyzed and compared. Finally, the shock response spectrum (SRS) of the SDOF system and the design flowchart for the TLECD are presented to provide a reference for shock vibration control of the SDOF system with the nonlinear TLECD and the design of TLECDs. The results show that there is an optimal dimensionless critical relative velocity that minimizes the dimensionless maximum damping force for reaching the target maximum displacement, and compared to the FVD, the TLECD greatly shortens the time to reach one-third of the maximum displacement.

Keywords: eddy current damper; nonlinear damper; impulsive excitation; vibration control; energy dissipation; shock response spectrum



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1. Introduction

Structural vibration control methods and devices have been well-developed to suppress vibration [1–3]. Unlike force loadings with a relatively long duration, impulse loadings are a special form of loading that can be applied to a structure in a very short period. In general, when the ratio of the duration of loading to the natural period $t_d/T_0 < 0.25$, the loading can be defined as an impulse [4,5]. In reality, impulsive loadings can be generated from many sources, including free-fall impacts, collisions, explosions, short-duration pulse-type seismic excitations, aircraft landing, braking loads, and many more. Although the duration of impulse loadings is relatively short, the peak forces exerted on the structure are usually quite high. As a result, the loadings can generate high responses and damage the structure consequently. This means that the design of the structure or the corresponding measures to prevent shock is crucial. In order to alleviate high responses caused by shock

Shock Vibration In Linear Systems

Christian Lalanne



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Shock and Vibration in Linear Systems Paul Arthur Crafton, 1961 *Mechanical Vibration and Shock Analysis, Sinusoidal Vibration* Christian Lalanne, 2014-05-12 Everything engineers need to know about mechanical vibration and shock in one authoritative reference work This fully updated and revised 3rd edition addresses the entire field of mechanical vibration and shock as one of the most important types of load and stress applied to structures machines and components in the real world Examples include everything from the regular and predictable loads applied to turbines motors or helicopters by the spinning of their constituent parts to the ability of buildings to withstand damage from wind loads or explosions and the need for cars to maintain structural integrity in the event of a crash There are detailed examinations of underlying theory models developed for specific applications performance of materials under test conditions and in real world settings and case studies and discussions of how the relationships between these affect design for actual products Invaluable to engineers specializing in mechanical aeronautical civil electrical and transportation engineering this reference work in five volumes is a crucial resource for the solution of shock and vibration problems The relative and absolute response of a mechanical system with a single degree of freedom is considered for an arbitrary excitation and its transfer function is defined in various forms The characteristics of sinusoidal vibration are examined in the context both of the real world and of laboratory tests and for both transient and steady state response of the one degree of freedom system Viscous damping and then non linear damping are considered The various types of swept sine perturbations and their properties are described and for the one degree of freedom system the consequence of an inappropriate choice of sweep rate are considered From the latter rules governing the choice of suitable sweep rates are then developed **Mechanical Vibration and Shock Analysis, Random Vibration** Christian Lalanne, 2013-03-04 *Mechanical Vibration and Shock Analysis Second Edition Volume 3 Random Vibration* The vast majority of vibrations encountered in a real world environment are random in nature Such vibrations are intrinsically complicated but this volume describes a process enabling the simplification of the analysis required and the analysis of the signal in the frequency domain Power spectrum density is also defined with the requisite precautions to be taken in its calculation described together with the processes windowing overlapping necessary for improved results A further complementary method the analysis of statistical properties of the time signal is described This enables the distribution law of the maxima of a random Gaussian signal to be determined and simplifies calculation of fatigue damage to be made by the avoidance of the direct counting of peaks The *Mechanical Vibration and Shock Analysis* five volume series has been written with both the professional engineer and the academic in mind Christian Lalanne explores every aspect of vibration and shock two fundamental and extremely significant areas of mechanical engineering from both a theoretical and practical point of view The five volumes cover all the necessary issues in this area of mechanical engineering The theoretical analyses are placed in the context of both the real world and the laboratory which is essential for the development of specifications

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Shock and Vibration Environment Wendell L. Hercules, 1962

Mechanical Vibration and Shock Analysis, Fatigue Damage Christian Lalanne, 2013-03-04 Mechanical Vibration and Shock Analysis Second Edition Volume 4 Fatigue Damage Fatigue damage in a system with one degree of freedom is one of the two criteria applied when comparing the severity of vibratory environments The same criterion is also employed for a specification representing the effects produced by the set of vibrations imposed in a real world environment In this volume which is devoted to the calculation of fatigue damage the author explores the various hypotheses and models used to describe the behavior of material suffering fatigue and the laws of fatigue accumulation He also considers the methods of counting response peaks which are used to establish a histogram when it is impossible to use the probability density of the peaks obtained with a Gaussian signal The expressions for mean damage and its standard deviation are established and other hypotheses are tested The Mechanical Vibration and Shock Analysis five volume series has been written with both the professional engineer and the academic in mind Christian Lalanne explores every aspect of vibration and shock two fundamental and extremely significant areas of mechanical engineering from both a theoretical and practical point of view The five volumes cover all the necessary issues in this area of mechanical engineering The theoretical

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