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Editorial

Nonlinear Vibration of Continuous Systems 2020

Francesco Pellicano,[1] **Matteo Strozzi**,[1] **Konstantin V. Avramov**,[2] **and Sinniah Ilanko**[3]

[1]*University of Modena and Reggio Emilia, Modena, Italy*
[2]*Anatolii Pidhornyi Institute of Mechanical Engineering Problems of the National Academy of Sciences of Ukraine, Kharkiv, Ukraine*
[3]*The University of Waikato, Hamilton, New Zealand*

Correspondence should be addressed to Francesco Pellicano; francesco.pellicano@unimore.it

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Scientific research in continuous systems, such as beams, membranes, plates, and shells, has continued to remain strong over several decades due to their role of fundamental structural elements of complex mechanical components in several engineering fields, e.g., aerospace, aeronautical, and automotive. In particular, since these continuous systems are typically designed for high-speed mechanical applications, it is important to investigate their nonlinear vibrations.

The present Special Issue collects eight original research contributions that focus on recent advances and developments in experimental techniques, numerical simulations, and theoretical models related to nonlinear dynamics of continuous systems. Specifically, these papers address the following areas of nonlinear vibration analysis: fault detection, diagnosis and prognosis, impact problems, damping and Coulomb friction, aerodynamic force and aeroelastic flutter, acoustic resonance, and complex shapes. From this collection of contributions dealing with different methods of nonlinear vibration analysis, it clearly shows both relevance and opportunity for the exchange of ideas between the Researchers of these areas. This was the main goal of the Guest Editors in proposing this Special Issue.

It should be underlined that the eight contributions received come from all over the world: Australia, China, Italy, Ukraine, USA, and Vietnam—this shows the generalized interest on the proposed topics. In the following, a short description of the content of the present Special Issue organized by grouping the contributions in different methods of nonlinear vibration analysis is reported.

1. Experimental Techniques

T. Q. Nguyen and H. B. Nguyen in the paper entitled "Detecting and Evaluating Defects in Beams by Correlation Coefficients" propose a new correlation coefficient for detecting and evaluating defects in beams. This parameter, which is defined starting from Pearson correlation coefficient, is proven, by means of experimental tests, to be more accurate and efficient than other classic parameters, such as natural frequency and damping coefficient, thanks to its high sensitivity to the structural changes. In particular, this new parameter is able to correctly detect increasing levels of defects and is sensitive to the position of the measurement channel, which is a very relevant factor for evaluating and locating defects in structural components, respectively.

The paper entitled "Probabilistic Assessment of Damage from Same Shock Response Spectra due to Variations in Damping" by A. Maji deals with the interpretation of field data from experimental shock tests and the subsequent assessment of product safety margins via laboratory testing based on shock response spectra (SRS). In particular, this work proposes a simple method of capturing damping from shock waves that can allow the original waveform to be more accurately reconstructed from the SRS. The decay rate associated with various shock wave frequencies is varied, leading to a variation in the acceleration vs. time history, which is correlated to a new parameter, referred to as "Damage Index," able to capture the fatigue damage imparted to the object under shock until failure.

2. Numerical Simulations

L. Ma et al. in the paper entitled "A Novel Aerodynamic Force and Flutter of the High-Aspect-Ratio Cantilever Plate in Subsonic Flow" derive a new analytic expression of the quasi-steady aerodynamic force related to velocity and deformation for a high-aspect-ratio cantilever plate under subsonic flow by adopting subsonic thin airfoil theory and Kutta–Joukowski theory. This theoretical aerodynamic force distribution is validated by means of comparisons with numerical simulations carried out via Ansys Fluent finite element software. The effect of aspect ratio, thickness, and air damping on the critical flutter velocity of the plate is investigated. Moreover, it is observed that, when the inflow velocity reaches its critical value, the limit cycle oscillation occurs.

The paper entitled "A Time-Discontinuous Galerkin Finite Element Method for the Solution of Impact Problem of Gas-Saturated Coal" by J. Zhang et al. presents a modified time-discontinuous Galerkin FEM based on the general Biot theory of the saturated porous media to simulate structural dynamics and wave propagation problems of gas-saturated coal in the presence of impact loading. Numerical results for 1D and 2D stress wave propagation problems show that this method gives more accurate solutions than standard time-discontinuous Galerkin FEM and Newmark method for the impact problems, as it can effectively capture wave discontinuities and filter out the effects of the spurious numerical oscillations induced by high-frequency impulsive load.

L. Chang et al. in the paper entitled "Aeroelastic Flutter and Sliding Mode Control of Wind Turbine Blade" propose a new aeroelastic flutter model of a pretwisted wind turbine blade based on damping analysis, considering the aeroelastic vibration instability and adopting the parameter fitting method. A numerical system for the sliding mode control is built by Simulink in order to simulate the flap and lead-lag directions of aeroelastic flutter. From these numerical simulations, it is obtained that the proposed sliding mode control algorithm significantly reduces the vibration frequency and therefore is able to suppress flutter-type blade aeroelastic failure under high wind speed and angle of attack.

The paper entitled "Numerical Study on Acoustic Resonance Excitation in Closed Side Branch Pipeline Conveying Natural Gas" by L. Jiang et al. describes an innovative delayed detached eddy simulation model developed to numerically simulate the flow-induced acoustic resonance problem arising in the closed side branch of a natural gas pipeline. This numerical study, which is performed by adopting the commercial CFD code (Fluent), investigates the coupling effect between flow and sound fields that causes acoustic vortex convection along the branch. The proposed model is shown to accurately capture acoustic resonance phenomenon and self-excited vibration characteristics of the considered pipeline with low computational effort.

3. Theoretical Models

The paper entitled "Steady-State Dynamical Response of a Strongly Nonlinear System with Impact and Coulomb Friction Subjected to Gaussian White Noise Excitation" by G. Yang et al. is devoted to the study of the steady-state dynamic behaviour of a strongly nonlinear system with impact and Coulomb friction under Gaussian white noise excitation. Zhuravlev nonsmooth transformation, Dirac delta function, and stochastic averaging method of energy envelope are adopted to obtain the steady-state probability density functions of the system. It is shown that different intensities of Gaussian white noise excitation can affect the peak value of the probability density functions, whereas the variations of restitution coefficients and friction amplitudes can induce stochastic bifurcations.

In the paper entitled "Vibrations of Plates with Complex Shape: Experimental Modal Analysis, Finite Element Method, and *R*-Functions Method" by A. Zippo et al., the dynamic behaviour of 3D-printed composite plates with different shapes and boundary conditions is studied. Specifically, natural frequencies and mode shapes of the plates are determined by means of the analytical *R*-functions method, numerical finite element simulations via NASTRAN software, and experimental tests. From the comparisons, by taking the experimental results as reference, it is found that, in the case of plates presenting rectangular cuts with clamped and free edges, the *R*-functions method provides better convergence with respect to FEM analyses.

At the end, the Editors hope that the content of the present Special Issue will be interesting and useful to the community of Engineers and Researchers working on nonlinear mechanical vibrations.

Conflicts of Interest

The Editors declare that they have no conflicts of interest regarding the publication of this Special Issue.

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