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Reliability of Response-Controlled Stepped Sine Testing for Experimental Detection of Nonlinear Structure

Abstract

Nonlinear structural dynamic analysis is required for mechanical structures experiencing nonlinearity through large force-vibration response ranges. Nonlinearities can be caused by large vibration displacements, material properties, or joints. Experimental modal analysis for nonlinear detection is achieved using conventional force-controlled stepped sine testing. However, this approach often encounters premature jumps in frequency response curves before reaching actual resonance peaks. In recent years, response-controlled stepped sine testing (RCT) has been introduced to quantify resonant peaks precisely. This approach, however, has only been limitedly utilised to detect and analyse nonlinearity in jointed structures and structures experiencing large displacement. In this paper, the reliability of the RCT approach is assessed for detecting nonlinearity from different sources. The experimental setup involves placing two magnets on opposite sides of a plate's free end to induce localised nonlinearity through magnet attraction. A low force magnitude of random excitation is employed to identify the frequency range of the first vibration mode using an electromagnetic shaker. Subsequently, RCT is performed within this range to measure the nonlinear forced response. Frequency response functions are measured at ten different controlled displacement amplitudes at the driving point. The analysis observed a symmetry curve of response in the measured FRFs. The results indicate that nonlinear hardening is detected at structures with localised magnet attraction. In conclusion, the reliability of applying the RCT approach for detecting nonlinearity from magnet attraction is achieved due to the absence of a jump issue in FRFs.

keywords

Modal analysis; Nonlinear detection; Nonlinear dynamic; Response-controlled stepped sine test; Structural vibration