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Detection of Contact-type Failure Based on Nonlinear Wave Modulation Utilizing Self-excited Ultrasonic Vibration (Evaluation of Failure Development Focusing on Frequency Modulation)

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Abstract. This research concerns the detection method of contact-type failure based on nonlinear wave modulation utilizing ultrasonic vibration driven by self-excitation. When the structure is vibrating by environmental force or forced excitation, the contact area is fluctuated by vibration. In this condition, the vibration transfer characteristics of ultrasonic vibration is fluctuated in synchronization with vibration (nonlinear wave modulation). The detection method based on nonlinear wave modulation can detect contact-type failure. In this paper, the novel detection method based on nonlinear wave modulation is presented. Firstly, the self-excitation method using the local feedback control is introduced. Local feedback control can oscillate at the natural frequency automatically. Secondarily, the concept of novel detection method is introduced. When the structure with contact-type failure is vibrating, the frequency of the ultrasonic vibration excited by local feedback control will be fluctuated in synchronization with natural frequency fluctuation. Nonlinear wave modulation is expressed 1 degree of freedom model. In this model, the local stiffness fluctuation is modelled by the spring element of which spring coefficient is fluctuated in synchronization with structural vibration. We regard the transfer function of this model as linear time-varying system. The amplitude of the fluctuation of natural frequency caused by stiffness fluctuation can be the novel index of failure level. Lastly, the result of the experiment using the uniform beam specimen is shown. From the relationship between forcing pressure of the contact-type failure and the amplitude of the frequency modulation, it is proved that the novel index is associated with failure level.

Keywords: Detection, Contact-type Failure, Ultrasonic, Nonlinear Wave Modulation, Self-excited Vibration.