Numerical investigation and detection of thermography.

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Abstract

Vibro-thermography is a promising nondestructive testing technique owning to its full-field and defect-selective imaging which excites ultrasonic waves to locally stimulate defects in large-scale and complex shape key components. In this paper, a low-power piezoelectric transducer was used as an actuator of vibro-thermography, and the detection and quantitative evaluation of the fatigue crack in metal structure were investigated. Experiments were conducted on an aluminum plate with a prefabricated fatigue crack. Both temperature data and thermal images were analyzed to validate the proposed method. The crack length was measured from the amplitude and phase image by the fast Fourier transform. The experimental error of crack length was less than 4.3% from the phase image.

Keywords: Elastography, Tactile imaging, Thermography, Medical photography.

Introduction

Fatigue crack is one of the main culprits for failures of in-service engineering structures, which causes up to 80 % of metallic structure failures. Under cyclic loading, fatigue crack usually initiates from unperceivable damage precursors such as dislocation or micro-crack, and gradually propagates and becomes conspicuous, which undergoes most of the total fatigue life for metallic materials. When the fatigue crack grows to a critical point, the crack unstably propagates, which leads to the immediate failure of whole structures. As a consequence, it is critically important to develop effective methodologies for detecting fatigue cracks and monitoring crack growth [1].

A robust non-destructive crack detecting technique is helpful to detect and measure fatigue crack length and propagation rate, which are important parameters in fracture mechanics analysis. The analysis results can substantially assist the decision-makers for proper actions regarding safety and minimization of the overhaul and repair costs due to fatigue cracks. Up to now, a number of techniques have been developed for detecting fatigue cracks and evaluating the crack length. Typically, visual inspection is often used to detect fatigue cracks and measure the crack length by magnifying device. Based on collecting and counting the acoustic signals induced by fatigue crack initiation, the acoustic emission AE technique is widely used in civil engineering for detecting and locating the fatigue crack. AE methods also have the potential for fatigue crack length estimation by some novel approaches. Both conventional linear and nonlinear ultrasonic techniques have been applied to monitor fatigue crack [2].

Non-destructive detection of coating thickness is important after coating deposition and during service. The present work is to establish a measurement method for fast inspection, large area detection of coating thickness with an active long pulse thermography. The measurement method was theoretically analyzed based on the equation of 1D heat transfer in the depth direction, accordingly coating thickness can be quantitively evaluated by recording the temperature decay curve in the cooling stage and computing the time at the minimum of its 2nd derivative. Then, the proposed method was experimentally validated by uniform coating specimen with different thicknesses. Furthermore, the thickness measurement method was successfully applied to measure thickness of an uneven coating specimen within a relative error of 5% with sufficient sampling rate [3].

Vibro-thermography is an active infrared thermographic technique for inspection of surface or sub-surface damages in engineering structures, such as cracks hidden corrosion delamination impact damage [and film thickness etc. The mechanism of heat generation in a vibrating structure includes frictional rubbing, plastic deformation, and viscoelasticity of the material. Frictional rubbing seems to be the dominant mechanism of heat generation in detecting cracks by vibro-thermography. There are many ways to stimulate mechanical vibration for the specimens. Sonic horn, typically used for welding plastics, was initially utilized to excite mechanical energy into the specimen and the delivered acoustic power is up to 1 kW. However, the uncontrolled generations of frequency component and excitation amplitude from the coupling between the specimen and horn, make experimental results highly non-reproducible and unreliable [4,5].

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Conclusion

In this work, detection of fatigue cracks in the metallic plate based on vibro-thermography was experimentally and numerically investigated. a low-power PZT transducer was employed to excite the aluminum specimen with a fatigue crack. The fatigue crack was quantitatively evaluated from the thermal image sequence. Furthermore, the finite element method was implemented to explore heat generation on the crack surface under ultrasonic stimulation.

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