Time-averaged vibration mode viewing with DSPI

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ABSTRACT

We discuss an experiment for detecting small deformations by speckle interferometry. Vibration modes of an aluminium plate are observed by digital speckle pattern interferometry (DSPI). A Mach-Zehnder interferometer arrangement is used and the speckle interferograms are recorded with a CCD camera and processed on a computer. These fringes depend on the path differences due to the vibration of the aluminium plate from its original state. Vibration amplitudes between 0.3 – 0.6 μm were measured for seven vibration modes.

Keywords: speckle, interference, speckle interferometry, vibrations, non-destructive testing

1. INTRODUCTION

The analysis of vibrations in mechanical and civil engineering has been a subject of interest for many decades. Non-contact testing methods have a considerable advantage over methods that require attaching large numbers of sensors to vibrating structures. Speckle methods have been used for various deformation measurements due to their simplicity of experimental arrangement[1].

A speckle interferometer uses the phenomenon that if a diffusely reflecting surface is illuminated by a coherent light source, a large amount of small light spots called speckles are formed by interference[2-4].

The objective of this paper is the development of a full-field non-contact system that can be used for temporal and spatial characterization of vibration patterns using a digital speckle pattern interferometer (DSPI)[5-15].

In the present work we investigate the vibrations of a square aluminium plate. Vibration modes of the plate are shown as speckle interferograms. As usualy is the case with such a technique we enhance the images on computer after recording. Processing of the interferograms implies filtering[8-10] in order to improve the signal to nose ratio (SNR) of the images.

2. SPECKLE INTERFEROMETRY

Illuminating a rough surface with coherent light will result in a granular pattern, because of the random spatial variation of intensity. Speckle effect appears only when the height variation of the surface is of the order of, or greater than the wavelength of the illuminating light. In a speckle interferometer, the laser beam is devided into two parts by a beam splitter. One beam, called the object beam, is illuminating the rough surface, the other is the reference beam and carries the phase information. Another beam splitter serves to combine the light from the two paths. An image forming optical system (e.g. a converging lens) is used to collect the diffused light from the object and project the image onto a CCD. Also, the beams are expanded in order to illuminate a larger area of the object and the dimension of the speckles is adjusted with an iris placed just before the imaging lens. The imaging lens and the viewing apperture gives what is called a subjective speckle. In such an arrangement, the spatial distribution of the speckle is determined by the diffraction limit of the imaging system. Thus, the maximum spatial frequency is determined by the size of the viewing lens aperture and the distance from the lens to the viewing plane (i.e. the focal length). The size of the speckles[8, 9, 12] will affect how sensitive the system is to decorrelation due to large movements of the object:

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