

Random Speckle Modulation Technique for Laser Interferometry

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In spite of its obvious advantages over conventional contact and immersion techniques, laser interferometry has not yet become a practical tool in ultrasonic nondestructive evaluation since its sensitivity is insufficient in most practical applications. Part of the problem is that the maximum signal-to-noise ratio often cited in scientific publications and manufacturers' specifications cannot be maintained on ordinary diffusely reflecting surfaces. Although these surfaces reflect a fair amount (5–50%) of the incident laser light, this energy is randomly distributed among a large number of bright speckles. Unless the detector happens to see one of these bright speckles, the interferometer's signal-to-noise ratio will be much lower than the optimum. This adverse effect is almost completely eliminated by the suggested random speckle modulation technique. The conventional interferometric technique was modified to assure random occurrence of a few very bright speckles and to move the whole speckle pattern around at an appropriate speed. Random but frequent bright flashes detected from the surface of the specimen resulted. The bright periods are 0.1 ms or longer, sufficient to trigger the ultrasonic pulser and detect the transmitted signals before the flash subsides. As much as 5–10 times improvement of the optical sensitivity was achieved by this novel approach and close to maximum signal-to-noise ratio was maintained everywhere on the surface of a diffuse object.

KEY WORDS: Ultrasonic remote sensors; laser interferometry.

INTRODUCTION

Ultrasonic methods have a very important role in nondestructive evaluation (NDE) of materials. Conventional ultrasonic techniques are based either on direct contact between the ultrasonic sensor (transducer) and the workpiece to be inspected or on liquid coupling when both the ultrasonic sensor and the workpiece are submerged in water. In many applications, especially in process monitoring, remote, noncontact ultrasonic sensors are desired. A promising noncontact method to couple waves without mechanical contact is a combination of pulsed laser generation and laser interferometric detection. The main advantage of optical remote sensing is

the ability to work in high-temperature (or otherwise hostile) environments and on rough surfaces, awkward shapes, and moving objects. The schematic diagram of laser generation and detection of ultrasound is shown in Fig. 1. The focused light of a high-power pulsed infrared laser irradiates a small spot on the surface of the specimen. The absorption of this very short (but intense) optical pulse causes localized heating and subsequent thermal expansion of the surrounding material. At higher laser intensities, some material at the surface may be vaporized, producing recoil forces in the specimen. Both mechanisms contribute to the generation of diverging acoustical waves in the sample; the waves can be detected at another point on the surface by a laser interferometer.

Recent development of inexpensive, neodymium-

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