NASA TECH BRIEF
Ames Research Center

Microwave Holography for Nondestructive Testing

Microwaves are of interest for nondestructive testing of propellant grains because they are cheaper to generate than x-rays and easier to manipulate. However, means must be found to form microwave images of the flaws from severely attenuated signals. Fortunately, holographic methods permit use of very large effective apertures so that weak signals can be collected over a wide area and integrated to form an image.

The microwave holographic technique is a modification of the side-looking radar principle, using frequency sweep instead of pulses to obtain depth resolution; moreover, the image-forming techniques common to side-looking radar can be used at the very short ranges needed for nondestructive inspection of test specimens.

In a waveguide system, the detector receives the reflected signal from the object and a sample of the outgoing signal in order to record a hologram. For depth resolution, the CW signal has been replaced by a linear full-band frequency sweep (12.4 to 18 GHz in the experimental work). The detector then receives two swept-frequency signals, one of which has a time delay proportional to the distance to the object. In practice, the sweep rate is adjusted so that the two signals overlap over almost all the sweep period. The detector output thus has a frequency output for each reflector in the beam. However, the swept-frequency range resolution does not produce a series of stacked, one-dimensional holograms as does a pulsed side-looking radar, which requires only an astigmatic lens system with correction for image-plane tilt; the hologram is actually two-dimensional (position along the scan line and distance to the specimen) and is difficult to process.

The method for image formation is described in reference to a sandbox simulator, in which rods or other representations of flaws can be inserted. To form the image in the optical processor, the transform plane filter is made by photographing the transform of a hologram made with no flaws in the simulator. This eliminates most of the background and greatly attenuates the back surface of the box; the front surface is completely eliminated. A cylinder lens performs focusing in one direction to produce the image, but first the lens is removed and the lateral focus of the image is observed. If, for example, three rods have been placed in the sandbox, they cannot all be brought into focus at once, and so they are recorded at different positions along the optical bench, appearing as bright vertical lines. Then a compromise focus is selected and the cylinder lens is replaced. The lens can focus all the images in the depth dimension and focus them in the same plane; it is moved to focus vertically in the plane selected as a compromise focus. In the resulting image, the lateral focus is better for some objects than others, but all are well resolved.

(continued overleaf)

Note:

Requests for further information may be directed to:

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NASA has decided not to apply for a patent.

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