DIAPHANIZATION BY ABSORBER COVERING

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I. INTRODUCTION

Diaphanization refers to techniques of reducing a target's radar cross section (RCS) and techniques of obscuring a radar image [1]. In the electronic counter measures applications target designers usually try to reduce the target's RCS to elude radar detection and to disguise the target's appearance so as to impede radar recognition.

Microwave diversity imaging using angular, wavelength and polarization diversity has been used to obtain images of metallic objects with nearly optical resolution [2]. The microwave images obtained by this imaging scheme have been satisfactorily interpreted, based on the understanding of the scattering mechanism of the metallic objects and the understanding of the image reconstruction algorithm [3]. That successful interpretation is fundamental to the diaphanization study.

In this paper we employ microwave diversity imaging to study diaphanization by absorber covering. In this imaging system the absorber-covered object is illuminated by a plane wave and the back-scattered field is received at a set of frequencies. The object is then rotated and the measurement is repeated. We study the diaphanization by the following approach: comparing the mean RCS, the range profile (defined as the Fourier transform (FT) of the back-scattered field), the sinogram (a two-dimensional intensity varied display with an abscissa of differential range, an ordinate of aspect angle, and intensity or brightness proportional to the magnitude of the range profile [3]), and the reconstructed image before and after absorber covering. We found this approach is very effective because the range profile provides range imformation about the scattering centers of the object for a particular aspect angle; the sinogram provides range motion information about the scattering center when the object is rotated; and the image pinpoints the positions of the hot spots (regions that contribute most to the scattered field) of the scattering object [1] over the specified spectral and angular windows. By comparing the above parameters before and after diaphanization, one can locate and identify the hot spots and evaluate the performance of diaphanization.

II. EXPERIMENTAL RESULTS

In this section we demonstrate and discuss some experimental results pertaining to the RCS, the range profile, the sinogram, and the reconstructed images of objects covered with absorbers. Because the RCS of interest is over a wide spectral bandwidth, we will compare the mean RCS, obtained by averaging the RCS at a single frequency. The spectral bands specified in this paper is from 6 GHz to 16.5 GHz. The absorber used are the Emerson Eccosorb AN72 broadband absorbers and Eccosorb GDS surface current absorbers [4]. AN72 is a light foam sheet absorber with thickness about 6mm. GDS is a thin (0.8mm), high loss, silicon rubber sheet. Contrary to the broadband absorbers, which are usually designed for reducing specular reflection or main-lobe reflection, surface current absorbers are designed to attenuate non-specular or side-lobe energy.

The tested object was an aluminum tube with one end covered by a cap and the other end open. Its geometry and dimensions are shown in Fig. 1. The antenna arrangement is shown in Fig. 2. The motivation for studying this object stems from its likeness to an engine intake. The tube is placed with its axis perpendicular to the rotational axis. The direction normal to the cap is defined as zero degrees. The co-polarized (with transmitting antenna righthand circularly polarized and receiving antenna lefthand circularly polarized) mean RCS pattern of the tube averaged over the whole band is shown in the solid curve of Fig. 3. Its sinogram is shown in the upper part of Fig. 4. Examining the sinogram, one can find that multiple reflections are important contributors to the back-scattered field when the rotation angle increases, which can be explained by the plot of the ray paths as shown in Fig. 5. The incident ray can be reflected to the receiver in the following way: (1). It can impinge on the rim of the empty mouth and then be diffracted to the receiver. (2). At a later time it may hit the rim of the back cap and be diffracted. (3). It may enter into the mouth, bouncing between the walls, be reflected back by the cap, and finally emerge from the mouth and propagates directly to the receiver. (4). The ray may reflect back from the cap, impinge on the rim of the mouth, and be diffracted to the receiver. The ray path lengths of cases (3) and (4) decrease as the rotation angle is increased as shown in Fig. 5, which explains the appearance of the sinogram.

Assume the angular window of interest is from ϕ=100° to 180°. Multiple reflections and rim diffractions are dominant scattering mechanism over this angular window. To reduce multiple reflections and edge reflections, we cover both sides of the cap with an AN72 broadband absorber, and cover the inner and outer rings of the mouth and the outer ring of the other end with a GDS absorber. The covered patterns are also sketched in Fig. 1(a). The mean RCS pattern after application of the absorber covering is shown in the dashed curve of Fig. 1(b). It is seen that the RCS after diaphanization has been reduced a great deal over the specified window. The sinogram after diaphanization is shown in the lower part of Fig. 1(c). It is seen that multiple reflections have been suppressed and the edge diffraction strength has also been reduced. The co-polarized images of the tube before and after diaphanization are shown in Fig. 6.

REFERENCE

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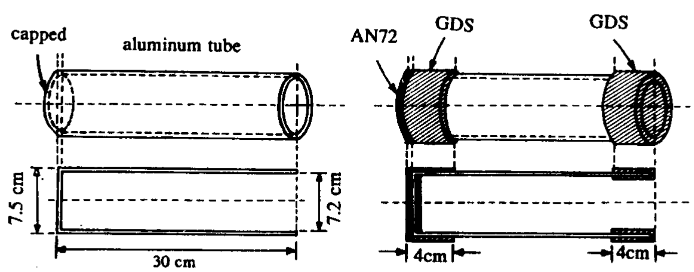

Fig. 1. Geometry of an aluminum tube and the sketch of the absorber covered regions.

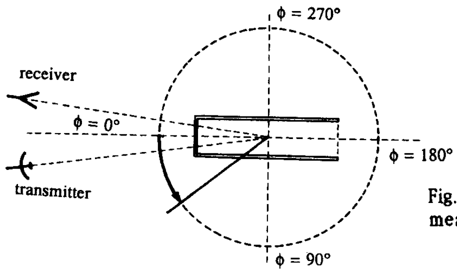

Fig. 2. Antenna arrangement of the measurement system.

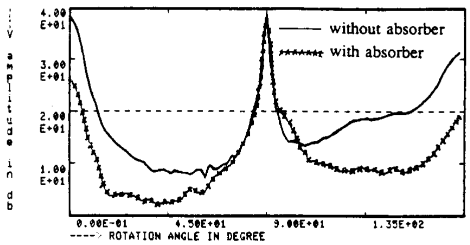

Fig. 3 Mean RCS patterns of the tube before and after absorber covering.

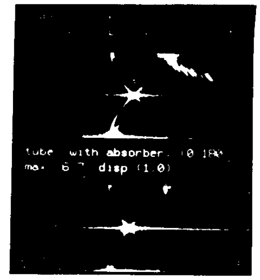

Fig. 4. Sinograms of the tube before and after absorber covering

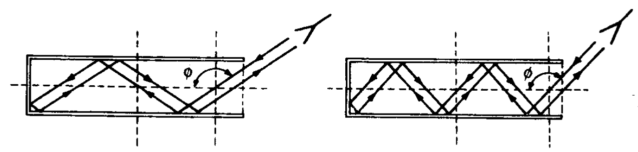

Fig. 5. Ray tracing of an incident wave traveling inside a hollow tube with a smaller rotation (left) angle and a larger rotation angle (right).

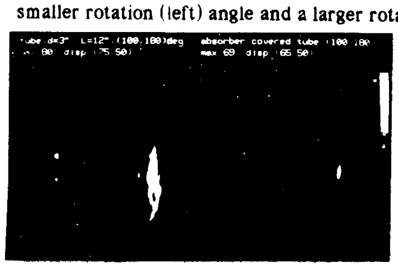

Fig. 6. Image before (left) and after (right) diaphanization reconstructed from the data collected over an angular window from ϕ=100° to 180°.