NDE2002 predict. assure. improve.
National Seminar of ISNT
Chennai, 5. – 7. 12. 2002
www.nde2002.org

NON DESTRUCTIVE EVALUATION OF CERAMIC RADOME

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ABSTRACT

The Ceramic radome was made by slip cast method using silica. It is a variable thickness radome. Non Destructive Evaluation (NDE) techniques such as Ultrasonic (Pulse Echo Testing), Radiography and Computed Tomography (medical) have been carried out to find out various defects like cracks, inclusion, porosity, density variations etc. The advantages and limitations of the NDE techniques in assessing the defects have been discussed.

INTRODUCTION

A Radome is a cover for radar transmitting and receiving antennas, which allows microwave transmission with the minimum loss and distortion, whilst protecting the equipment from the environment.

The aim of this paper is how to select a particular NDE method for radome to detect the various defects like cracks, inclusions, porosity and density variations and characterize them. The best approach is always the method selected that gives the most efficient results for a given application. If possible a combination of such techniques can be used to the greatest benefit. Therefore NDE methods such as Ultrasonic (Pulse Echo Testing), Radiography and Computed Tomography (medical) have been tried out.

Conventional NDE techniques like Ultrasonic and X-ray Radiography have been employed to study the defects in radomes and analyze them. More advanced and the state-of-art techniques like Computed Tomography (CT) have also been employed to substitute the inadequacies in testing by conventional NDE techniques and to make use of advanced features available for effective analysis.

Generally ceramic radomes are porous in nature. The couplant used (oil & epoxy resin) for Ultrasonic (PET) seeps through the radome and cause inconvenience for the testing and hinder with its electromagnetic performance.

Film Radiography and Computed Tomography have been employed as non-contact techniques on radomes to overcome couplant seeping problems and inaccessible areas for inspection without any hindrance.

EXPERIMENTAL PROCEDURE

X-ray radiography was carried out in Normal mode. Initially, digital radiography of the radome was taken by CT, selected the slices and cross-sectional images were taken. Computed Tomography (CT) was carried out using medical CT and the parameters were 120 kV, 160 mA, 4.5 Sec. The slice thickness was 1mm. The contrast in the tomograms was measured in terms of linear attenuation coefficients in Hounsfield Units (HU). 2-D images were stacked one over the other and the 3D image was generated to see the extent of defects. However, digital radiographs obtained by CT only presented for discussion due to their high sensitivity.

RESULTS AND DISCUSSION

Fig. 1 shows the digital radiograph of the radome. The horizontal lines seen across the radome indicate the locations where cross sectional images obtained by CT. Fig. 2 shows the cross sectional image of the radome near the tip. The contrasts in the tomograms were measured in terms of linear attenuation coefficients in Hounsfield Units (HU). The variations in HU measured in Fig.2 indicate that there is a density variation. In medical CT, Water is assigned as 0 HU, Air is assigned as –1000 HU and the remaining materials are assigned accordingly. Similarly W.A. Ellingson et al.,[1] used CT and studied variations in density in ceramics.

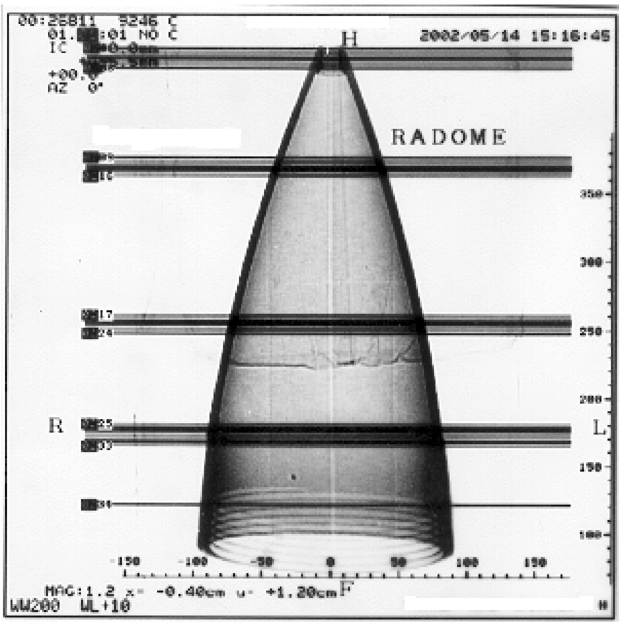

FIG.1 : Digital radiograph of Radome.

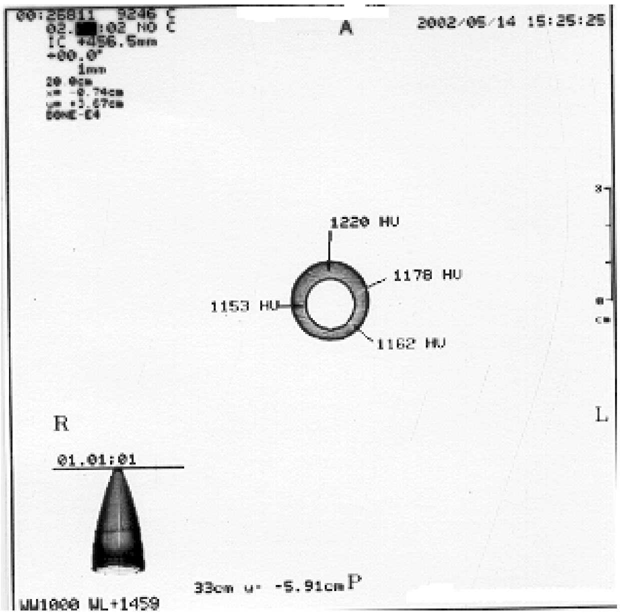

FIG.2 : CT cross sectional image of Radome near tip

Fig. 3 shows the density profile taken along a line on the cross-sectional image of the radome to differentiate between the defects and air gaps. It is clear from fig. 3, that there were no air gaps seen along the thickness of the radome because there was no sudden dip seen below zero at that location. Fig. 4 shows the reconstructed image obtained from the 2-D images, which were stacked one over the other and cut at the location. This 3D image was generated to see the extent of the defects. The above features are not available in radiography. These features enhance the defect detection capabilities and increase the confidence level in defect detection. However, tomograms of the radomes inspected revealed only density variations and no defects like crack, inclusion.

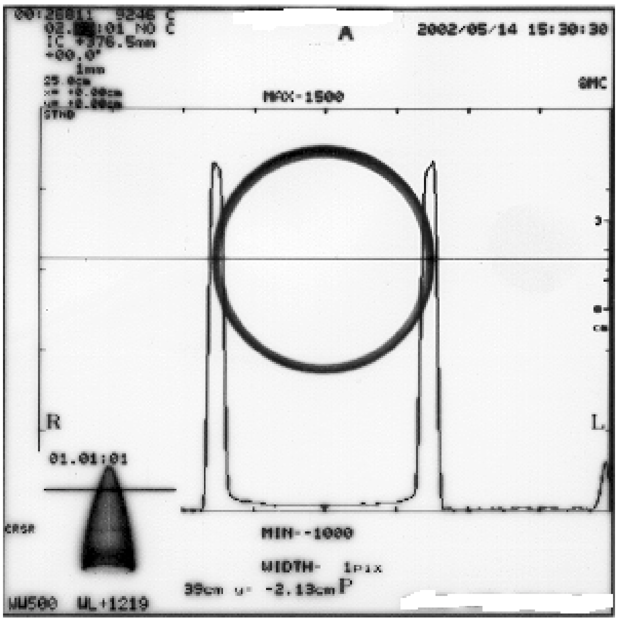

FIG.3: Density Profile of a Cross-sectional slice

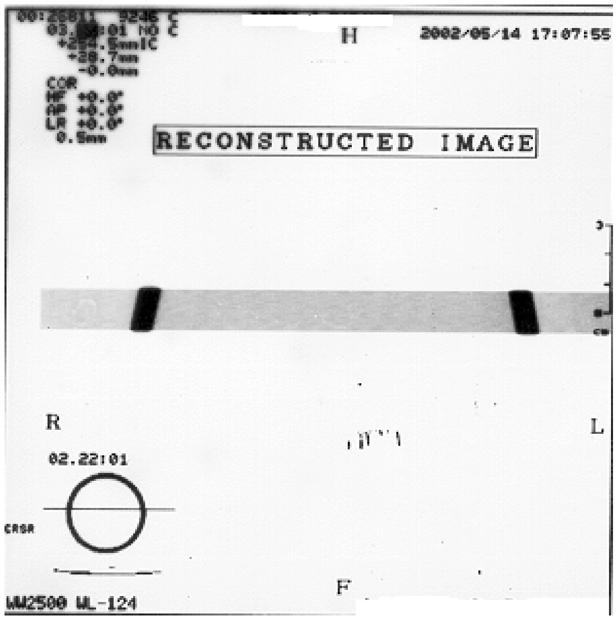

FIG.4 : Reconstructed Image generated from 2D slices

Fig. 5 shows the cross sectional image of the contrast phantom. The contrast phantom consists of 3 cylinders viz., Pyrex, Polyethylene and Teflon embedded in a bigger Perspex (PMMA) cylinder. The purpose of scanning this contrast phantom was to demonstrate that all the above materials with varying in their densities could be clearly identified. Fig. 6 shows the cross sectional image of the Resolution phantom. The resolution phantom consists of a rectangular Perspex block made of rectangular holes drilled alternatively (as seen in fig. 6) with 0.63 line pairs/cm (equal to a resolution of 7.94 mm) to 9.80 line pairs/cm (equal to a resolution of 0.53 mm) respectively. The resolution obtained with the phantom at present was 6.17 line pairs/cm (corresponding to a resolution of 0.81mm). This means the defects, which were 0.81mm and above could be resolved. Contrast and resolution bar phantoms are generally used for measuring the CT system performance parameters and also for calibration of the system.

FIG.5: Cross-sectional image of a contrast phantom

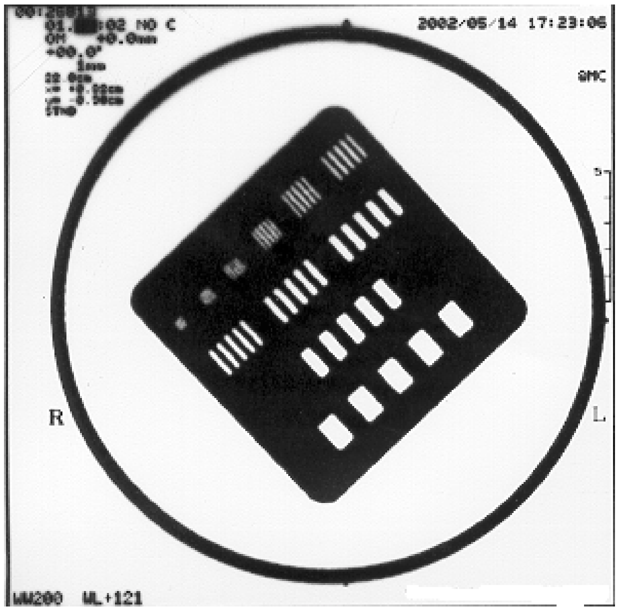

FIG.6 : Cross-sectional image of a resolution phantom

CONCLUSION:

Ultrasonic (PET) could not be used due to couplant seepage in radome. Radiography and CT were identified as NDE techniques for evaluation of defects in Radome. However, CT was emerged as a forerunner NDE technique over Radiography due its effective analysis and depth of information obtained. The features like measurement of attenuation coefficient in HU units, density profiles and reconstructed image from 2D slices place CT much ahead over other conventional techniques in terms of defect detection and confidence level.

REFERENCES:

1. W.A. Ellingson, P.E. Engel, T.I. Hentea, K. Gopalan. P.S. Wong, S.L. Dieckman and N. Gopalsami, Tropical Proceedings of Industrial Computerized Tomography, July 25-27, 1989 Seattle, USA, pp 10-14.