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MICROCT ANALYSIS TOOLS FOR GRFP LAMINATED JOINTS INSPECTION

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ABSTRACT

Combinations of different materials are known as composite materials. As there are several types of composites, there are several Non-Destructive Testing techniques to inspect them, each with its own characteristics. In this context, the Computed Microtomography is a powerful tool used for the volumetric analysis of internal structures or to generate images in three dimensions (3D). The purpose of this study is to provide a methodology for the analysis of joints of polymer composite tubes. For this, the matrix volumes, reinforcement and defects of some samples were checked.

Keywords: MicroCT, Laminated Joints, 3D Analysis

NOMENCLATURE

GRFP	Glass Fiber Reinforced Polymer
microCT	Computed Microtomography
ROI	Region of Interest
VOI	Volume of Interest

1. INTRODUCTION

The simplest definition of composite materials establishes this type of material as the mixture of two or more components, or distinct phases [1]. The processing of composites is called molding. To process a composite is to impregnate the reinforcement with a given matrix, so that, at the end of the process, the solid component with well defined geometry is practically in a position to be used [2]. Attention during processing increases the quality of the composite causing subsequent repairs (machining or thinning) to be minimally required. Composite processing methods depend on several factors [3]. The simplicity of Hand Lay-up molding involves no investment in process equipment for manufacturing. However this type of processing can result in composites without structural commitment and with a high percentage of nonconformities [4-5].

Over the years, several failure criteria specific to composite materials have been described in the literature to predict the quality of these materials [6]. The inspection techniques that use ionizing radiation have been promising for this type of inspection, since the heterogeneity of the composites provides an excellent contrast in images [7-8].

This study was carried out with the objective of demonstrating a methodology to evaluate joints of GFRP laminated tubes inspected by microCT, exploring the applications of image processing and qualitative and quantitative analysis.

2. MATERIALS AND METHODS

Four 6 inch (nominal diameter) GFRP pipe joints were inspected using a V|tome|x M (GE) microCT system. The acquisition of the images and reconstruction of the solids were performed through the software provided by the system manufacturer. The CTAn (v. 1.18.4.0) software was used to calculate morphometric parameters such as: Total volume contained in VOI (TV, mm³) and percentage of VOI occupied by objects (matrix, reinforcement and defects). The CTvox (v. 3.2.0 r1294) software was used to create the volume of defects.

3. RESULTS AND DISCUSSION

By opening the images in the CTAn it is possible to identify the tube region, the impregnated layers of matrix and reinforcement and some nonconformities present in the sample. The next step is to create the ROI that refers to a transverse slice of the sample. The VOI is the sum of all transverse slices and represents the volume over which all analyzes will be performed. The samples are of laminated joint, so it will be necessary to interpolate two regions of interest so that the center (empty) and the part of the tube (which is not of interest) are discarded from the analysis.

After the determination of the VOI, the segmentation (binarization) of the images was performed. This process uses the thresholding method to identify matrix phases, reinforcement and defects. Figure 1 shows the separate and binarized phases.

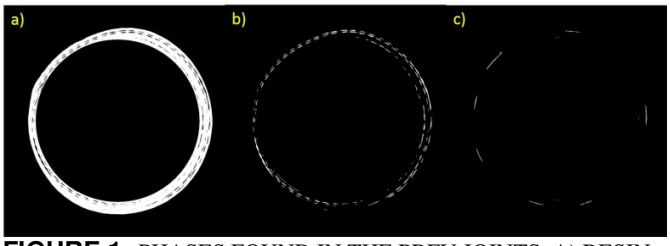

FIGURE 1: PHASES FOUND IN THE PRFV JOINTS. A) RESIN. B) REINFORCEMENT. C) DEFECTS.

The basic analyzes provide data such as total volume contained in VOI (TV, mm³) and percentage occupied by binarized objects, in this case, matrix, reinforcement and defects. For all joints evaluated, the mean percentage of matrix and reinforcement was of 91.6% and 6.1%, respectively, of the total volume analyzed. Delamination or debonding defects and voids were found. The percentage was less than 1% of the total volume analyzed in all cases.

For the application in laminated composites, it is interesting to use 3D structural thickness analysis (St.Sh) method, since it can provide a differentiation between the types of defects that may arise. Figure 2 shows the frequency distribution of objects found in each size range.

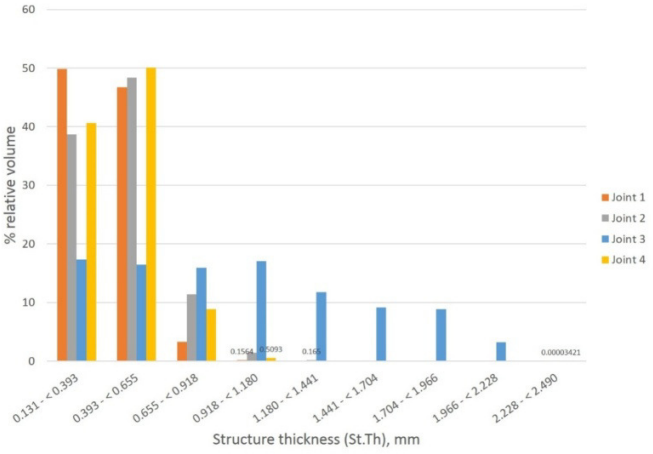

FIGURE 2: 3D STRUCTURE THICKNESS OF DEFECTS OF ALL SAMPLES

When performing thickness analyzes of the structures, grayscale images, which characterize the thicknesses, can be generated. These images can be equalized through the CTVox software as shown in Figure 3 and it becomes a way to qualitatively demonstrate the acquired results.

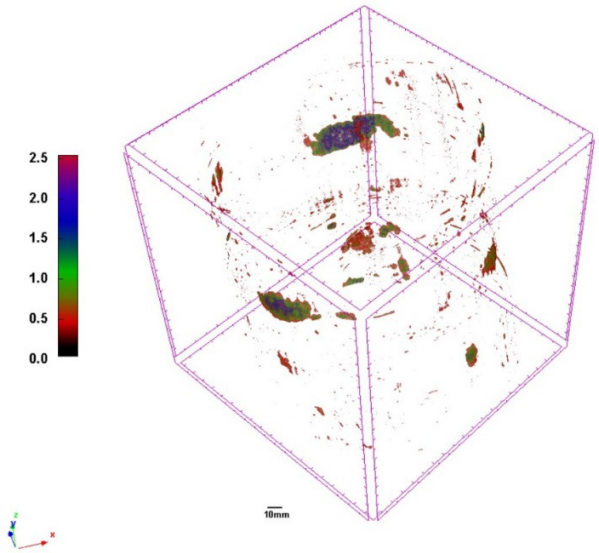

FIGURE 5: EXAMPLE OF QUALITATIVE ANALYSIS OF JOINT DEFECTS

The software VGStudio Max also offers possibilities of analysis. For the purposes of information only, Figure 4 demonstrates the possible types of visualization for this type of sample. It is possible to plan images of various geometries in order to carry out a study of their structures.

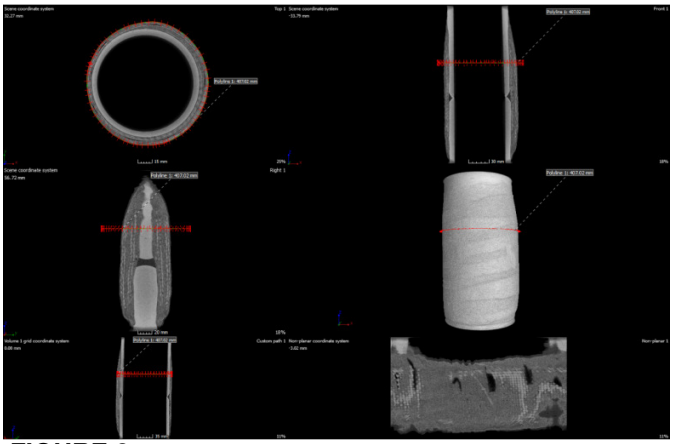

FIGURE 8: EXAMPLE VGSTUDIO ANALYSIS OF THE JOINT DEFECTS

4. CONCLUSION

MicroCT is a powerful non-destructive tool and its application in the inspection of composite GFRP has increasingly required the resources of the segmentation and analysis software. The aim of this work was to demonstrate a way to analyze this type of sample that, due to its structural complexity, makes segmentation difficult to perform. Factors such as determination of the binarization threshold are essential for compromising the results, as they may produce wrong results. We consider the observation of defects in relation to thickness to differentiate defects is of great value. However, further studies should be carried out in order to add contributions to this type of inspection.

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