3rd International Conference on Tomography of Materials and Structures
Lund, Sweden, 26-30 June 2017, ICTMS2017-18

INTERNAL GEOMETRY ANALYSIS OF DISCONTINUOUS CARBON FIBER REINFORCED THERMOPLASTICS WITH TWO MICRO-CT METHODS

Yi Wan*[1], Ilya Straumit[2], Stepan V. Lomov[2] & Jun Takahashi[1]

[1] The University of Tokyo, Department of Systems Innovation, Hongo 7-3-1, Bunkyo-ku, Tokyo, Japan
[2] KU Leuven, Department of Materials Engineering, Kasteelpark Arenberg 44 B-3001, Leuven, Belgium

Keywords: x-ray tomography, carbon fiber reinforced polymer (CFRP), microstructural analysis, CT analysis.

Summary: The present work proposes X-ray micro CT based methods to measure and quantify the meso-structural property of two different kinds of discontinuous CFRTP. One is the general carbon fiber mat composites and the other is the randomly oriented strands (ROS). The multi-scale orientation distribution quantification and the visualization of fiber morphology were characterized.

1. INTRODUCTION

Carbon fiber reinforced polymer (CFRP) generally applied to the industries where high mechanical performance and weight reduction are required. Thermoplastics show less hazardous composition and better in-plant recyclability compare with conventional thermoset resins. Consequently, researches focusing on carbon fiber reinforced thermoplastics (CFRTP) and their potential applicability in different industrial fields have increased in decades [1].

In the present work, one kind of carbon fiber mat composites named carbon fiber paper reinforced thermoplastics (CPT) and one kind of randomly oriented strands (ROS) named ultra-thin chopped carbon fiber tape reinforced thermoplastics (UT-CTT) were manufactured through compression molding for the research of meso-structure analysis. Two different computed tomography (CT) methods were proposed to measure and quantify the internal geometry of UT-CTT after the X-ray images of the material were collected using X-ray scanner. One method is the general image binarization processing, which can simply separate the fibers from the matrix based on the gray value of the image. Another method based on the structure tensors generated from the gray value distributions of the CT structures [2, 3]. After the meso-structure of the composites were rebuilt by the two image processing methods, the multi-scale fiber orientation distributions, the tape morphology and the 3D structure and orientation misalignment were discussed in detail.

2. EXPERIMENTAL METHOD

The composites were manufactured with heat-and-cool compression molding, the fiber volume fraction (V_f) of the UT-CTT is 55% in average and the CPT is 20 % in average. Both the material were composed with carbon fibers and polyamid-6. The raw materials of UT-CTT were provided by the Industrial Technology Center of Fukui Prefecture and the raw materials of CPT were purchased from the Awa Paper Mfg. Co., Ltd. The specimens for X-ray measurement are prepared. The 2*2*20 mm specimens were cut from the plates for this study. 3D X-ray scanner (TDM1000-II from Yamato Scientific Co., Ltd.) were used to collect the meso-structure images. The specimens were fixed on a rotating stage, and the 3D X-ray images were collected during the rotation of the stage.

Two different CT image processing methods were adopted in the present study. The two methods were conducted through different software with different algorithm. One software named TRI/3D-BON (RATOC System

* e-mail: wan-yi@cfrtp.t.u-tokyo.ac.jp

Engineering Co., Ltd.), and the basic algorithm of this software based on the general image binarization process. Another software named VoxTex, which is developed by the composite materials group (CMG) from the Department of Materials Engineering (MTM), KU Leuven [2-4]. The basic algorithm of this software based on the three-dimensional grey value structure tensor of the stacked X-ray images.

3. RESULTS

In this study, two different X-ray CT methods were proposed to measure and quantify the meso-structure properties of UT-CTT. The results indicated that the TRI/3D-BON method can provide satisfactory high resolution orientation visualization (fiber monofilament level) and average orientation degree (orientation tensor), also the reconstructed visualization 3D model of the composites can provide straightforward cognition of the internal geometry properties. On the other hand, the VoxTex method show advantage in the quantification and visualization of multi-scale fiber orientation distributions, especially the two-scale orientation of the tapes and of the fibers inside the tapes in UT-CTT. The visualization 3D model reconstructed by this method can be easily extracted to subsets, and using the threshold definition, the specific tape morphology can be extracted from the model for detail analysis. Furthermore, the orientation misalignment of the tapes can be given by the unfolded histograms of in-plane orientation (Phi_XY) and the tape waviness can be calculated by the unfolded histograms of out-of-plane orientation (Theta_XY).

References

[1] J. Takahashi, T. Ishikawa. Next challenge in CFRTP for mass production automotive application. SEICO 14 SAMPE EUROPE 35th International Conference and Forum, Paris, France2014.
[2] M. Barburski, I. Straumit, X. W. Zhang, M. Weyers, S. V. Lomov. Micro-CT analysis of internal structure of sheared textile composite reinforcement. Composites Part a-Applied Science and Manufacturing. 2015;73:45-54.
[3] Ilya Straumit, Stepan V. Lomov, Martine Wevers. Quantification of the internal structure and automatic generation of voxel models of textile composites from X-ray computed tomography data. Composites Part A: Applied Science and Manufacturing. 2015;69:150-158.
[4] Yi Wan, Ilya Straumit, Jun Takahashi, Stepan V. Lomov. Micro-CT analysis of internal geometry of chopped carbon fiber tapes reinforced thermoplastics. Composites Part A: Applied Science and Manufacturing. 2016;91, Part 1:211-221.

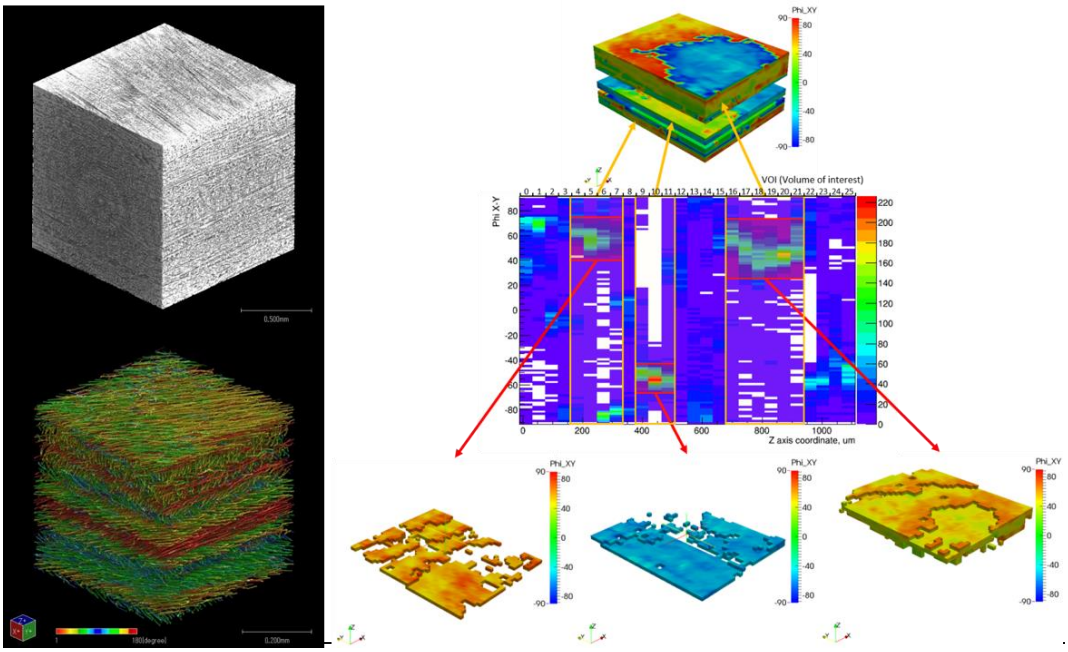

Figure 1: The samples of microstructure CT analysis of UT-CTT use TRI/3D-BON method (left) and the VoxTex method (right).