Damage Evolution of 3D Woven Carbon/Epoxy Composites under the Tension-Tension Fatigue Loading

Jinzhao Huang, Xinyang Sun, Li Zhang, Licheng Guo*

Department of Astronautic Science and Mechanics, Harbin Institute of Technology, Harbin, China

*Corresponding author: guolc@hit.edu.cn

Abstract

The 3D woven composites, first developed in 1960s, have been paid more and more attention due to their high delamination resistance, fracture toughness, damage tolerance and shape designability comparing with laminates and 2D woven composites[1]. The fatigue damage evolution study on 3D woven carbon-fiber reinforced composites has been a challenge to research community. In this paper, a multi-scale method is proposed to investigate the tension-tension fatigue damage evolution of 3D woven carbon/epoxy composite. Axial stiffness degradation and surface temperature rise is used to characterize the macroscopic fatigue damage. In addition, the synchrotron radiation computer tomography (SRCT), an advanced detection technology for carbon-fiber reinforced composites[2, 3], is used to detect the internal fatigue damage evolution. The SRCT detection system is shown as Fig.1. According to the stiffness and surface temperature results, a similar law of damage evolution is found. To study the damage types at different stages of stiffness degradation, three samples are subjected to different numbers of cycles before detecting by SRCT. With this method, the 3D crack initiation and propagation can be recorded by the SRCT scanner. According to the observation results, the interface debonding and transverse crack in the yarns are the main damage types before final fatigue failure. Based on the multi-scale results, the fatigue damage mechanism is analyzed in depth.

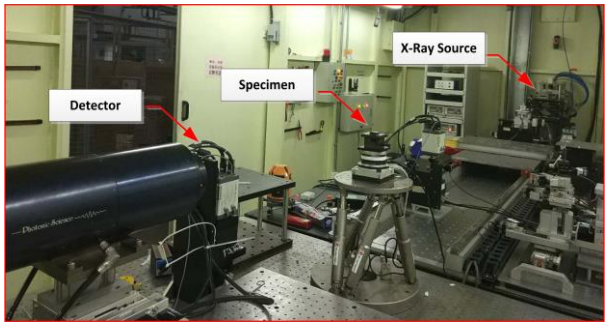

Fig.1 SRCT detection system

Acknowledgment

This work was supported by Natural Science Foundation of Heilongjiang Province (ZD2019A001). The authors are grateful to Shanghai Synchrotron Radiation Facility, Dr. Yanan Fu (SSRF) who gave helpful advice to the work.

References

[1] A.P. Mouritz, M.K. Bannister, P.J. Falzon, K.H. Leong, Review of applications for advanced three-dimensional fibre textile composites, Compos. Pt. A-Appl. Sci. Manuf. 30(12) (1999) 1445-1461.

[2] D.J. Bull, S.M. Spearing, I. Sinclair, L. Helfen, Three-dimensional assessment of low velocity impact damage in particle toughened composite laminates using micro-focus X-ray computed tomography and synchrotron radiation laminography, Compos. Pt. A-Appl. Sci. Manuf. 52 (2013) 62-69.

[3] Z.X. Li, L.C. Guo, L. Zhang, Q.M. Wang, In situ experimental investigation on the out-plane damage evolution of 3D woven carbon-fiber reinforced composites, Composites Science and Technology 162 (2018) 101-109.