Very High-Cycle Fatigue Characteristics of Cross-Ply CFRP Laminates in Transverse Crack Initiation

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Carbon fiber reinforced plastic (CFRP) laminates are lightweight and have excellent mechanical properties. Thus, they have been used not only for aircraft fuselages and wings but also for engine parts. Especially, fan blades are subjected to very high cyclic loadings during the design life, so it is essential to evaluate the giga-cycle fatigue characteristics of CFRP laminates. In this study, the transverse crack initiation of the cross-ply CFRP laminates in very high-cycle fatigue region was evaluated using an ultrasonic fatigue testing machine. The cross-ply $[0/90_4]_s$ CFRP laminates were formed from interlaminar toughened type prepreg, T800S/3900-2B, with fiber volume fraction of $V_f = 56\%$ and cured at 453 K in an autoclave. The fatigue tests were conducted at the frequency of $f = 20$ kHz and the stress ratio of $R = -1$. In order to suppress temperature rise of the specimen, the intermittent operation with the loading time of 200 msec and the pausing time of 2000 msec was adopted. The fatigue life data to transverse crack initiation in very high-cycle fatigue region was compared with the data of the fatigue test which was conducted at the frequency of $f = 5$ Hz and the stress ratio of $R = 0.1$ using a hydraulic control fatigue test machine. Figure 1 shows the transverse crack observed on the specimen edge surface at the $N = 4.3 \times 10^8$ cycles and under the test condition of initial maximum strain of $\varepsilon_{max} = 0.15$ %. The transverse crack passed through the thickness and width directions of the specimen perpendicular to the loading axis. Figure 2 shows the fatigue life diagram to the transverse crack initiation. It was evaluated considering the influences of the stress ratio and the thermal residual stress by using the modified Walker model [1]. The vertical axis of the graph was expressed with the product of the normalized maximum stress and stress amplitude applied in 90° layers of the cross-ply laminates. From this results, the fatigue life to the transverse crack initiation of the cross-ply CFRP laminates in the very high-cycle region exceeding 10^8 cycles was on the extension of the test data in the low cycle region.

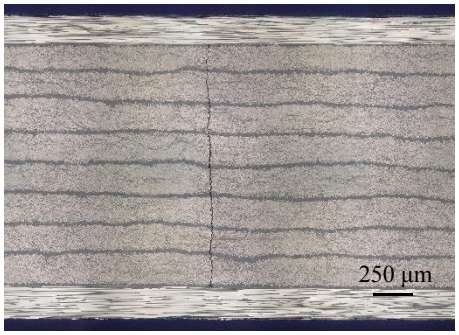

Figure 1. Transverse crack observed on the specimen edge surface.
($\varepsilon_{max} = 0.15$ %, $N = 4.3 \times 10^8$ cycles)

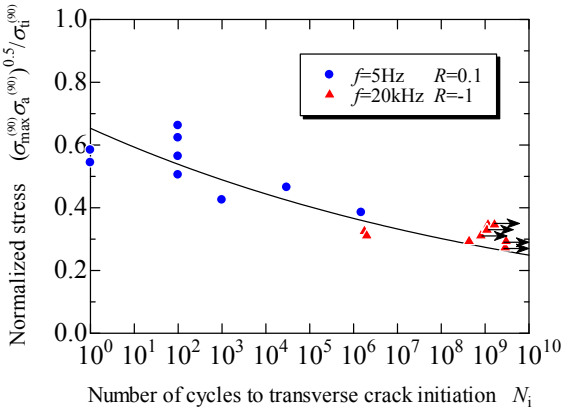

Figure 2. Fatigue life diagram to transverse crack initiation.

Keywords: Very-high cycle fatigue, CFRP, Transverse crack

References

[1] Atsushi Hosoi, Hiroyuki Kawada, Fatigue life prediction for transverse crack initiation of CFRP cross-ply and quasi-isotropic laminates, Materials, 2018, 11(7), 1182.