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Characterization of Fatigue Damage in Composite Laminate Using Lamb Wave Velocities

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Composite laminates suffer from fatigue damage under cyclic loads and one direct result is the stiffness degradation due to transverse matrix cracks in off-axis plies. Since the Lamb wave velocities are decided by the stiffness properties of materials, it is reasonable to use Lamb wave to characterize the fatigue damage in composite laminates. For this to be achieved, an explicit solution for 0-frequency S_0 and SH_0 mode phase velocities is deduced in this work, based on which a damage evolution law is further proposed combined with shear-lag model and Paris model. The proposed damage evolution law was then used to characterize the fatigue damage in both cross-ply GFRP laminates ($[0/90_3/0/90_3]_s$) and quasi-isotropic GFRP laminates ($[45/0/-45/90]_{2s}$), where the experimental S_0 phase velocity was obtained by a laser ultrasonic scanning system. The illustrated results in Fig. 1 and Fig. 2 show good agreements between numerical calculations and experimental data. With the proposed damage evolution law, it is possible for future work to be done to inspect and predict the residual fatigue life of composite laminates using Lamb wave velocities.

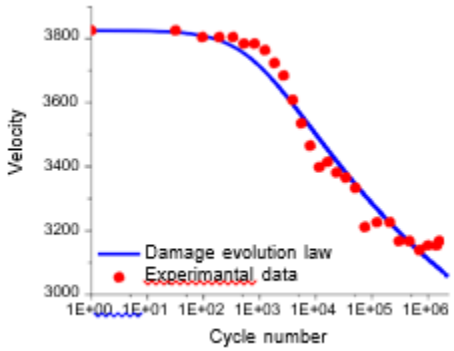

Figure 1. Fatigue damage characterization of a cross-ply laminate.

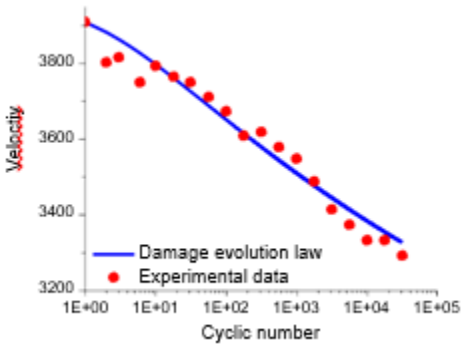

Figure 2. Fatigue damage Characterization of a quasi-isotropic laminate.