FRACTURE MECHANISM OF DELAMINATION UNDER FATIGUE LOADING – EFFECT OF MICROMECHANISM

M. Hojo*[1]

[1] *Department of Mechanical Engineering and Science, Kyoto University, Sakyo-ku, Kyoto 606-8501, Japan*
**hojo_cm@me.kyoto-u.ac.jp*

The start of the regular flights for Boeing 787 and the final assembly for Airbus A350XWB promise that carbon fiber reinforced plastics (CFRPs) become common materials for the primary structures of commercial aircraft. Although composite materials have significantly greater resistance to fatigue loading than other classes of materials, experimental results show that the damage in CFRP structures accumulates under fatigue loading. Moreover, the interlaminar strength, whose importance has been recognized for more than thirty years, is still one of the design limiting factors in composite laminated structures, as witnessed in the troubles of the wing-to-body join for B787 giving delay of the development. Then, improvement and accurate understanding of fatigue delamination is still the current topics for composite materials.

The methods for increasing interlaminar strength are classified either as improvement of the materials (matrix resin systems and fiber/resin interface) or as modification of the fiber architecture. One of the established means of material improvement is to replace resin at the prepreg interface with a tougher system. A commercial carbon fiber (CF)/epoxy with a heterogeneous interlayer has successfully been used in the primary structures of Boeing 777 and 787 [1]. Since cyclic plastic deformation is the cause of fatigue, the improvement in toughness of CFRP laminates with tougher resin system is often not fully translated into the improvement in delamination fatigue resistance.

Placing fibers in the loading direction through the efficient use of fiber architecture is a more direct method for achieving significant improvement in interlaminar strength. Among plenty of through the thickness reinforcement methods, entangling in-plane yarns with each other in thickness direction with special needles (Zanchor) is quite a promising technique, in which interlaminar strength can be improved inexpensively together with liquid resin molding. Since fibers are oriented in the thickness direction, more direct translation of static toughness to fatigue delamination resistance is expected [2].

In this lecture, effects of resin toughness on delamination fatigue are reviewed first. Then, the fracture micromechanism of Zanchor reinforced laminates is presented both under static and fatigue loadings [2,3]. The roles of fiber, matrix and interface in fatigue delamination are discussed based on review of current experimental researches using micro model composites [4].

References

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