IJIMM International Journal of the Institute of Materials Malaysia (IJIMM) Volume 1, Issue 2
www.ijimm.org

Prediction of First Transverse Crack Formation in Cross-Ply CFRP Laminates under Fatigue Loading

Atsushi **Hosoi**[*1], Ken **Kurihara**[2], Narumichi **Sato**[3], Hiroyuki **Kawada**[1]

[1]Department of Applied Mechanics and Aerospace Engineering, Waseda University
[2]Graduate School of Fundamental Science and Engineering, Waseda University
[3]Composite Materials Research Laboratories, Toray Industries, Inc.
3-4-1, Okubo, Shinjuku-ku, Tokyo, Japan 169-8555

*Corresponding author's phone: +81-3-5286-2354
E-mail: hos@aoni.waseda.jp

Date Received: 27th June 2014
Date Revised: 14th July 2014
Date Accepted: 14th July 2014

ABSTRACT

The formation of a first transverse crack in cross-ply carbon fiber reinforced plastic (CFRP) laminates was predicted under fatigue loading and the fatigue limit of transverse crack initiation was evaluated quantitatively. Transverse cracks induce more serious damage, such as delamination or fiber breakage. It is essential to understand the mechanism of the transverse crack initiation for improving long-term durability of CFRP laminates. Therefore, a method was proposed to predict the number of cycles to transverse crack initiation in cross-ply CFRP laminates under fatigue loading. Two types of cross-ply CFRP laminates, $[0/90_6]_s$ and $[0_2/90_{12}]_s$, of different thickness were used for fatigue tests. As the results, we were successful in predicting the number of cycles to transverse crack initiation under fatigue loading and evaluating the fatigue limit of the transverse crack initiation by the proposed analysis. Moreover, it was found that the fatigue life to transverse crack initiation in $[0/90_6]_s$ laminate was approximately 50 times longer than that in $[0_2/90_{12}]_s$ laminates.

Keywords: CFRP; transverse crack initiation; fatigue

1.0 INTRODUCTION

The specific strength and stiffness of carbon fiber reinforced plastics (CFRPs) make them well suited as a structural replacement for lightweight metallic materials. However, because fatigue fracture is a major failure mode of machinery and structures that incorporate metals, it is necessary to examine the fatigue properties of CFRP laminates to establish whether their long-term durability and reliability are favourable as well. CFRP laminates that are subjected to cyclic loading are susceptible to matrix cracks, delamination and fiber breakage. Specifically, the first sign of damage in CFRP laminates undergoing cyclic loading is the development of transverse cracks in 90° plies; these cracks trigger the more critical damage modes of delamination and fiber breakage. Thus, it is important to predict transverse crack initiation under cyclic loading.

Various experimental and analytical studies on the multiplication and propagation of transverse cracks under static and cyclic loading have previously been reported. And also the studies on the initiation of a transverse crack under static loading have been conducted [1, 2]. However, few analytical studies have quantitatively addressed transverse crack initiation under cyclic loading. Takeda et al. [3] showed that the initiation of transverse crack could be predicted by assuming that an initial microcrack propagates to the thickness direction of a ply following the Paris law. However, the size of the initial microcrack and the constants of the Paris law are decided arbitrarily in the study. Ogi and Yashiro [4] proposed a probabilistic method to predict the initiation of transverse crack under fatigue loading. However, the usability is not cleared because the analytical results are not compared with the experimental results. On the other