EXPERIMENTAL ANALYSIS OF COMPOSITE STRUCTURES DEBONDING UNDER CYCLIC LOADING

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Introduction

Composite structures are widely used in aerospace applications due to their good fatigue resistance and light weight. Today skin/stiffener interfaces are not designed towards fatigue loading according to manufacturer's policy. However, optimizing the mass of the structure will require postbuckling to occur under limit loads thus requiring fatigue behavior to become a design basis. As of today, little data exist on the fatigue debonding of Skin/Stiffener. First investigations have been performed on the effect of pressure loading on a composite materials bonded fuselage panel [1]. Three and four point bending static tests on this type of structures have been realized [2]. Fatigue damage mechanisms investigation and the influence of stacking sequence interface (skin/flange) on the fatigue life were the objective of many works [3, 4]. The objective of this work is to investigate the fatigue damage mechanisms of the interfaces in laminated carbon aeronautic structural parts T700/M21. Here, technological specimens named "stringer foot specimen" are loaded in four point bending tests under cyclic loading. This study presents the influence analysis of two types of interfaces, ((0°/0°) or oriented (+45°/-45°)) and on the local designs effects (Straight edges or Tapered edges). Fatigue tests are carried out under load control for three load levels corresponding to 33%, 47% and 66% of the monotonic bending strentgh. Microscopic investigations are used to determine the onset of delamination, trajectory and speed propagation of the crack.

Experimental

Materials and Specimen Preparation

The material used in this study is the unidirectional T700/M21 with the density of 134g/m^2. The nominal ply thickness is 0.13 mm. Test specimens were manufactured by hand layup. The polymerization environment is in conformity with Airbus recommendation. The skin and flange laminate were co-cured without an adhesive film. The skin was composed of 16 symmetrical plies and the flange of 14 ones. Flange thickness was 1,82mm.

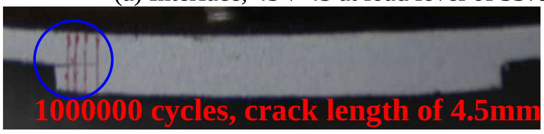
Apparatus and Procedures

Fatigue tests were performed in a servo hydraulic Instron universal testing machine with a 100kN capacity and a 0,5mm/min crosshead velocity. These tests have been achieved under load control at a load ratio R=0.1 using a sinusoidal wave form. The specimens were cycled at a frequency of 4Hz. The cyclic loading was stopped depending on the load level and a camera takes a photograph every 100, 1000 and 10000 cycles to document the occurrence, onset delamination and crack propagation.

Results and Discussion

During fatigue tests, the onset delamination occurs between the skin and the flange for both configurations (Straight edges or tapered edges). In the case of the straight edges (interface 0°/0° or 45°/-45°), the crack propagates slowly with the number of cycles (see fig. 1a-b). The interface oriented to 45°/-45° seems to delay the initiation of the fatigue crack as shown in fig 2. Furthermore, the tests showed that these interfaces slow down significantly the crack propagation, and even that this crack deviates upward until it reaches the first ply at 0°. On the other hand, Tapered edges significantly delay the initiation of delamination compared to straight edges (fig. 3). Furthermore this configuration (Tapered edges), exhibits a faster crack propagation than the Straight one. The positive role of Tapered edges which delay the initiation of delamination is then reduced by this faster and then more critical crack propagation.

(a) Interface, 45°/-45 at load level of 33%



(b) Interface 0°/0°, at load level of 66%

Fig. 1 Typical damage patterns in co-cured specimens with Straight edges configuration.

Conclusion

Fatigue tests on carbon specimens with two configurations (Straight edges or Tapered edges) were performed. The fatigue tests results were presented in standard S/N diagrams.

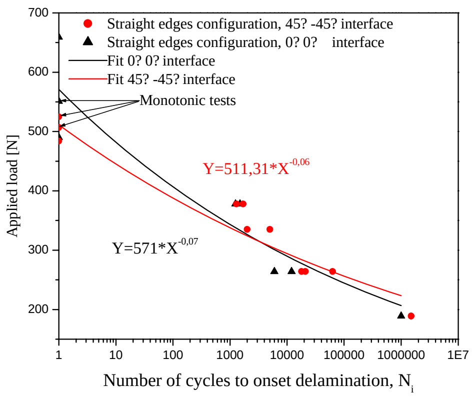


Fig. 2 Maximum cyclic load as a function of the number of cycles to delamination onset for Straight edges.

It was found that in the case of he straight edges (Interface 0°/0° or 45°/-45°), the crack propagates slowly as well as, the interfaces oriented to 45°/-45° allow to delay the fatigue crack onset. While, the specimens with Tapered edges allow to delay the initiation of delamination.

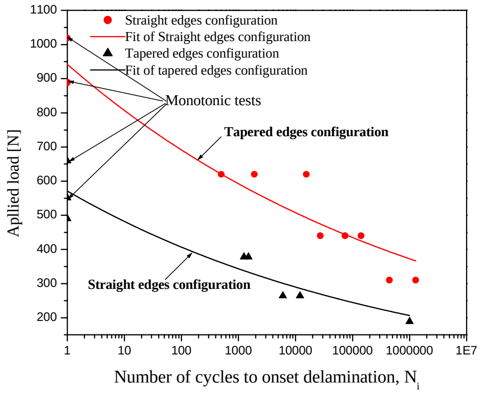


Fig. 3 Maximum cyclic load as a function of the number of cycles to delamination onset for both configurations.

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