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Technical Report

Comparison between double and single sided bonded composite repair with circular shape

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ABSTRACT

In this study, a new approach is applied to compare the performances of single sided and double-sided symmetric composite patch with circular shape for repairing cracked aircraft structures. This is an approach that consists to evaluate the mass gain eventually obtained by the use of double symmetric composite patch if the two patch configurations give the same stress intensity factor at the crack tip. The three-dimensional finite elements method is used to compute the stress intensity factor. The obtained results show that the use of the double patch technique leads to a significant reduction of the stress intensity at the crack tip. The mass gain eventually given by the double patch technique can be very significant and this gain depends on the patch shape and the adhesive properties.

1. Introduction

The use of externally bonded composite patches for repairing crack and defects in aircraft structures knows a large success these last years, what accelerated the researches in this domain. The scientific approach to designing and assessing repairs has probably started in the early 1970s. Alan Baker pioneered the researches in this field at the Aeronautical and Maritime Laboratory (AMRL) of the Royal Australian Air Force (RAAF) [1]. The bonded composite repair carries a part of the loads acting at the crack tip throughout the adhesive. This technique is promising because composite laminates are non-corroding, conformable and easy to fabricate and have high rigidity and strength.

The analysis of stresses distribution and the fatigue life of repaired structures are the most used approaches to evaluate the repair performances. Rose [2], Bachir Bouiadjra et al. [3] and Callinan et al. [4] used the finite elements method to analyze the performances of the bonded composite repair. They showed that the presence of the patch repair highly reduced the stress intensity factor (SIF) at the crack tip, what can improve the fatigue life of the cracked structures. Atluri, [5] and Chow and Atluri [6] applied the finite element analysis (FEA) to model composites bonded to metals. In their works, the numerical results were compared with the experimental data. They showed that the bonded composite repair improved the durability of aircraft structures under practical application conditions.

The analysis of the effects of the geometrical properties of the composite on the repair performance got great interest in the literature. Heller and Kaye [7] used the genetic algorithm to optimise the patch shape. Kaddouri et al. [8], Ouinas et al. [9,10] analyzed numerically the performance of the octagonal, circular and elliptical shapes of the patches. They showed that the patch shape has a significant effect on the value of the stress intensity factor at the crack tip. In addition, the use of appropriate patch shapes can reduce the level of the thermal residual stresses due to the adhesive curing.

Bachir Bouiadjra et al. [11] showed that the adhesive properties must be optimised in order to allow the transmission of the stresses toward the patch and to avoid the adhesive failure. Concerning the mechanical properties of the patch it is known that only the boron/epoxy and the graphite/epoxy are used because of their excellent load transfer characteristics [1]. One can conclude that the improvement of the patch performances by the assessment of the properties of the composite and the adhesive proves to be more complex and expensive. The unique parameter that remains is the patch thickness. Bachir Bouiadjra et al. [11] showed that for single patch repairs the increase of the patch thickness about 50% reduces the stress intensity factors at the same order and they concluded that for a better distribution of the stresses, it is preferable to use a multiple layers of bonded composite patch. One of means that can strengthen these ideas is the use of the double-sided symmetric patch. The comparison between the double and single symmetric patch was analyzed by several authors [12–18]. They showed that the use of double symmetric patches improve the fatigue life of the repaired structures. This improvement is due to the double stress transfer in the double patch configuration. In addition, the double

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