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Numerical and experimental investigation of fitting tolerance effects on damage and failure of CFRP/Ti double-lap single-bolt joints

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Abstract: CFRP/Ti bolted joints are increasingly used in aircraft structures. Optimizing the joint design is vital for overall composite structure designs. Therefore, a progressive damage model was developed for investigating the effects of clearance and interference sizes on the damage and failure of CFRP/Ti double-lap, single-bolt joints under quasi-static loads, in which the improved three dimensional Hashin failure criterion and Tan degradation rules were used through an ABAQUS user-define-field (USDFLD) subroutine. The corresponding quasi-static tensile tests and fatigue tests were also conducted. Joints strength were evaluated and failure mechanism was discussed. Numerical results showed that the matrix compression failure dominated the joint failure mode. Joint ultimate strength decreased gradually with the increase of clearance sizes, while joint bearing strength and stiffness exhibited an increase with interference sizes at first and then decreased rapidly due to the initial installation damage. Moreover, the maximum strength was achieved at the interference size of 0.5%. Those results were in well agreement with corresponding experimental results. In addition, interference sizes were also revealed a correlation with the fatigue life of the joints. The study presented here will be useful for optimization of composite structure designs.

Key words: composite; bolted joint; clearance; interference; damage

1. Introduction

Carbon fiber reinforced polymer (CFRP) composites are increasingly applied in modern aviation industry, which have advantages of high specific strength, specific stiffness, fatigue design, corrosion resistance [1-4]. For example, the fuselages of both Boeing 787 and Airbus A350XWB, which are two characteristic examples of the latest generation of large commercial aircrafts, are manufactured with the amount of composites more than 50% in weight. Although the composite structures of aircraft have been developed toward the integration of design and manufacture, the joining